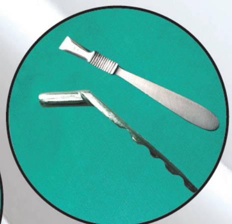
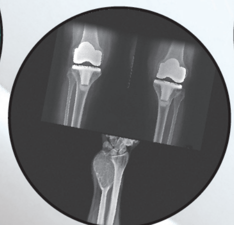
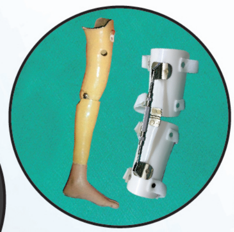
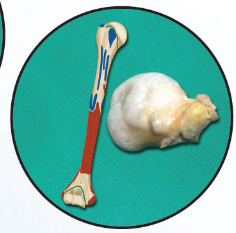
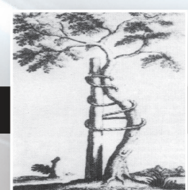
BEDSIDE CLINICS IN ORTHOPEDICS

(Ward Round and Tables)

Upendra Kumar

Forewords

DK Taneja
Anil K Jain
Sudhir Kapoor

JAYPEE

BEDSIDE CLINICS IN
ORTHOPEDICS

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(Ward Round and Tables)

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A Tribute to Padma Bhushan
Dr (Professor) B Mukhopadhyay
The Pole Star of Orthopedics

Who was the Founder of Orthopaedic Research and Education Foundation (OREF), India

ORTHOPAEDIC RESEARCH AND EDUCATION FOUNDATION
1983
EXCELLENCE WITH SAFETY

Dedicated to

My wife Dr Jyoti Bala and kid Gunnu

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Foreword

The practical examination is a clinical examination starting from bedside manners to history taking, eliciting clinical signs and making a clinical differential diagnosis. Unfortunately, all these aspects are very much lacking in the present set-up of training. After three years, when students face senior examiners who ask basic questions on clinical examinations, the students start fumbling. In spite of the fact that the student has good theoretical knowledge.

In order to bridge this gap, I have been conducting the special course for postgraduate students. It has become very popular and largely students have very much benefited. Dr Upendra Kumar also attended my course, and at present, he is my youngest faculty member too. What we teach and what all is discussed, has been tried to compile very systematically in a book form.

It is a very good effort by a young orthopedic surgeon. It is commendable indeed. After going through the book, I feel that it will prove very handy and useful. It covers all aspects of the examination, and it will help students to clear their practical examination in a single attempt. In the first phase of the book, *Ward Round and Tables* is in your hand, and its *Clinical Methods and Cases* unit will be available very soon.

DK Taneja
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Past Secretary General, Orthopaedic Association of SAARC Nations
Secretary, Orthopaedic Research and Education Foundation, India
Secretary General, World Orthopaedic Concern

Foreword

I am extremely happy to write the foreword of *Bedside Clinics in Orthopedics (Ward Round and Tables)*. I have known Upendra Kumar, when he used to attend postgraduate courses for his DNB training. His questions used to reflect the confusion in the mind of orthopedic trainees on getting variable responses to the same question. The practical training in orthopedics includes day-to-day patient care procedures, performed in ward/outpatient/operation theater. It is quite common to get a variable answer to the same question in ward round, practical examinations and viva voce. Through this book, he has tried to crystallize the answers to such practical training issues.

Orthopedics as a subject has grown exponentially. The trainee not only has to learn theoretical knowledge but also to acquire psychomotor skills with a clear understanding of its rationale. There exists a lacuna in the current educational resource material on practical training subjects. The learning resources on the subjects of clinical/practical importance are not being updated and available as one book. The author has attempted to fill the vacuum.

The book is divided into eight sections—Ward Round, Table of Instruments and Implants, Table of Orthopedic Radiographs, Table of Orthosis and Prosthesis, Bone, Joint Model and Specimen, Orthopedic Surgical Approaches, Operation Theater and Sterilization, and Glorious History of Orthopedics. Each section has been broken into multiple subject titles, and each subject title is given a theoretical knowledge, practical application with rationale. This format will not only improve the understanding of practical procedures performed day-to-day by orthopedic trainees but also improve the treatment outcomes.

I am sure this book will not only be useful to all orthopedic trainees but will also be a guide for practicing orthopedic surgeons.

Anil K Jain
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Past President, Indian Orthopaedics Association
Ex- Editor, Indian Journal of Orthopaedics
Deputy Editor, Journal Bone and Joint Surgery (Am)
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The Tamil Nadu Dr MGR Medical University
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Foreword

The standard of postgraduate education in India, unfortunately, is not uniform. This holds true for both Medical Council of India (MCI) and National Board of Examination (NBE) run courses. Students at few centers are relatively at a disadvantageous position for educational purposes. Though this will is there, but appropriate educational material is not there. I am referring to paucity of basic educational material which is focused for our students in India, to clear their examinations.

The effort, made by Dr Upendra Kumar, in this regard becomes significant in view of the above observations. He has been able to provide a concise compilation in the form of a book for postgraduate students in orthopedic surgery, for their postgraduate exit examination.

I must also appreciate the sincerity of Dr Upendra in this regard. He, though not working on a teaching faculty position in a medical college, has succeeded in bringing out the book because of his sheer devotion to the cause.

I am sure this book, which is focused, well compiled and nicely laid out, would be received well by the orthopedic postgraduate students.

Sudhir Kapoor
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Lady Hardinge Medical College, New Delhi
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The Tamil Nadu Dr MGR Medical University, Chennai, Tamil Nadu
Member
Research Board, Aligarh Muslim University and Banaras Hindu University, Uttar Pradesh, India
President, Indian Orthopaedic Association

Preface

Rightly said, the most of the useful and valuable things have been invented in difficult and demanding situations. In the same manner, the cornerstone of this book has been laid down during those harsh conditions when orthopedic postgraduates (DNB) students were not getting success even after their 2nd or 3rd attempts of their practical examination in different parts of the country.

By discussing these issues with Dr DK Taneja (Indore), Dr VK Goyal (New Delhi) and Dr VK Sinha (Patna); we started to construct a treatise that can guide our DNBs, masters and diploma students in proper direction and lighten the pathway of success. The preparation of this book is also influenced by Orthopaedic Research and Education Foundation (OREF), India, established by Dr B Mukhopadhyay. This foundation is working continuously for orthopedic education for postgraduates throughout the country. We have prepared the book not for commercial purposes but as contribution in the field of orthopedics.

The book stands up to the mark, which is informative, illustrative, comprehensive and with sufficient content. Although the facts included in the book are obtained from various sources, hence, we are thankful to all orthopedic personnel and publishers throughout the globe, who have given their direct or indirect contribution in this regard. Hence, please do not look this issue as copyright, but treat it as your contribution if any.

The present edition contains ward rounds and tables, instruments and implants, orthopedic radiographs, orthosis and prosthesis, bone, joint model and specimen, surgical approaches along with principle of operation theater and sterilization, and glorious history of orthopedics. We are coming soon with its clinical version including history taking, clinical methods, long and short cases and important viva voce questions. Although this is clinical notes, hence students are requested to always go through standard textbooks.

Despite of meticulous corrections, there might be possibility of human error. Useful critics and suggestions are always invited from teachers, seniors, colleagues and juniors to make it more productive and fruitful. This is also a time to remember the living legends of orthopedics of India such as Dr Shailendra Bhattacharya (Kolkata), Dr Surendra Mohan Tuli (Delhi), Dr GS Kulkarni (Miraj), and Dr Hardash Singh Sandhu (Amritsar). Our generation is fortunate to have such great orthopedicians.

In the last, I express my heartiest gratitude to the Chairman (Dr John Mukhopadhyay) and Secretary (Dr DK Taneja) of OREF, who always provided a back support on this project. I also thank my colleagues of Patna Medical College, Patna, and Deen Dayal Upadhyay Hospital, New Delhi, for their constant support and supply of material for this cause.

Finally, I offer this book to the young buds of orthopedic world with a big salute to my all teachers throughout the country.

Upendra Kumar

What Teachers Say About this Book

The present examination systems are made to judge the clinical knowledge of students, but they are caught in very trivial things. This book serves the purpose of the students, especially for the examination. Every student undertaking the examinations of different levels such as diploma, degree or DNBs must go through this book to get the feel of the examination prior to facing the examiner.

VK Sinha
Head
Department of Orthopedics
Patna Medical College and Hospital
Patna, Bihar, India

For a long time, there was a need for a book which can help our postgraduates in practical examinations when they have gone through ward round and tables and viva voce. Because it needs an exhaustive collection of material from different sources. I would like to congratulate Dr Upendra, who understood these problems and wrote a title over it.

Alok C Agrawal
Head
Department of Orthopedics
All India Institute of Medical Sciences
Raipur, Chhattisgarh, India

Students should learn the proper methodologies of patient examination, ward care and other wings of practical knowledge. This book stands out and provides comprehensive information required for practical examination for orthopedic postgraduates when they gone through ward round and tables viva voce. Students will find this book very useful and informative.

VK Goyal
Former Head, Department of Orthopedics
Deen Dayal Upadhyay Hospital
New Delhi, India

Most of the practical issues of orthopedics such as ward care, interpretations of X-rays, knowledge of instruments and implants, etc. are missed or forgotten by postgraduates. One of the surest ways to recover these lost things is going through this book. Added on to it are some critical insights which would be benefiting to those who aspire more. The way of delivery is very simple in this text, hence, postgraduates can easily reproduce it in their examinations.

Dileep Basu Mazumdar
Head
Department of Orthopedics
Malda Medical College and Hospital
Malda, West Bengal, India

First of all, I would like to congratulate Dr Upendra Kumar, who realized the various practical problems of postgraduates and residents throughout the country. This book will not only introduce the budding orthopedic doctors to basic inpatient management but also help them for their postgraduates practical tables viva voce. It will prove a ready-reckoner for seniors also. I congratulate him for his serious efforts.

RC Meena
Head
Department of Orthopedics
SMS Medical College and Hospital
Jaipur, Rajasthan, India

I am happy to know that Dr Upendra Kumar, a young dynamic orthopedic surgeon, who is my student also, has prepared a treatise *Bedside Clinics in Orthopedics (Ward Round and Tables)*. It is a beautiful collection of various practical materials being used in day-to-day practice. I sincerely hope that this new book will be helpful not only for postgraduate students who want to persue MS/DNB orthopedic course but also for residents and junior specialists.

S Keshkar
Head
Department of Orthopedics
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Bedside Clinics in Orthopedics (Ward Round and Tables) has been prepared for post-graduates to improve their practical knowledge of orthopedics. It is like a gift by Dr Upendra Kumar for exam-going postgraduates and DNB candidates. Residents may also be benefitted with this treatise.

CP Pal
Head
Department of Orthopedics
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I would like to congratulate Dr Upendra for lifting such a responsibility on his young shoulder. In the first look, one can say how much time and hard work have been spent to prepare this ready reckoner. The chapters of the book are arranged in a beautiful manner and ornamented with many original photographs. It comes under the category of must-have books. Side-by-side, it is an excellent finisher like MS Dhoni for postgraduates and residents too.

Lalit Maini
Associate Professor
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New Delhi, India

What Readers Say About this Book

I passed my DNB (secondary) practical examination held in June 2016. I used the raw material form, which is now in the book form, and answered my examiner confidently. It appears that hardly any important thing has been left that is expected from a postgraduate trainee. It was a game changer for me and I hope it will be a pathfinder for many others. Thank you sir.

K Dinesh
Erode, Tamil Nadu, India

After getting the material what have taken a form of a book now, I got an outlook of a professional preparation. More so, they are presented in such a nice pattern that it was very easy to grasp. I had very little time for practical, so I solely read this material, and surprisingly, I could not only answer most of questions in viva voce but also cleared examination in the 1st attempt. I feel this book is for all DNB and MS candidates. Thanks a lot sir.

Piyush Prabhat
Patna, Bihar, India

It is an ultimate material for postgraduates. My DNB practical result in the first attempt is its proof. I have never seen such kind of practical book where you can find all practical materials in one, which not only helps you in examination but also it increases your knowledge of orthopedics. I say, very thanks to Dr Upendra sir for creating such a valuable book with his hardwork.

Rajiv Munde
Mumbai, Maharashtra, India

Sir, I am thankful to you for such a great collection of material under one cover. Every postgraduate trainee must be acquainted with this basic knowledge. This preparation helped me to crack tough nut, i.e. DNB practical examination. I would like to recommend this book to every orthopedic postgraduate for his/her success.

Amitosh Mishra
Lucknow, Uttar Pradesh, India

I am deeply indebted to Dr Upendra Kumar's *Bedside Clinics in Orthopedics (Ward Round and Tables)*. It is the most comprehensive and yet concise compilation of orthopedic practical material for postgraduates. It boosted my confidence and helped me to clear my practical examinations in the first attempt.

Naman Wahel
Bikaner, Rajasthan, India

What I am at present is only due to focused guidance of Dr Upendra Kumar and his book prepared for ward round and tables. When I passed that was my third attempt for DNB practical examination and I had a time of only one month for it. I got my success in this hard time only due to Dr Kumar's effort and guidance.

Afzal
Uttar Pradesh, India
Working in Kuwait

I felt lucky to read this book before its launch and it did wonders for me. This book is very well written, and includes most of the information required to master practical examination. Simple and crisp language makes it very easy-to-read and understand. This is must and best available book needed to clear any orthopedic practical examination.

Rahul Goyal
Alwar, Rajasthan, India

I have used this book before its launch. This book has been nicely compiled with great hard work. It has been judiciously divided into different table viva voce and ward round. It is a collection of almost everything needed for practical examination. It will prove to be a milestone in the journey of orthopedic books.

Sunny Chaudhary
Shamli, Uttar Pradesh, India

Contents

Section 1: Ward Round

Section 3: Table of Orthopedic Radiographs

Section 5: Table of Bone, Joint Model and Specimen

Section 6: Orthopedic Surgical Approaches

Section 7: Operation Theater and Sterilization

SECTION 1

Ward Round

Upendra Kumar

Chapters

CHAPTER

1

Casting Materials and Orthopedic Casts

Although casting persisted as an integral part of conservative treatment in orthopedics from 18th century. Hence, the basic knowledge of materials used in casting is of utmost importance. Side by side principle of reduction and their maintenance is also important.

PLASTER OF PARIS BANDAGE (FIG. 1.1)

- First used by Matthysen Dutch military surgeon in year 1858.
- *Characteristics:*
  - Plaster of Paris (POP) impregnated bandage.
  - *Setting time:* 4–5 minutes.
  - Full strength of cast is achieved in 24–48 hours.

Fig. 1.1 Plaster of Paris bandage

  - Chemical reaction—plaster of Paris (calcium sulfate hemihydrate) is obtained by heating gypsum (calcium sulfate dihydrate). And again when plaster of Paris comes in contact of water, gypsum reappears with release of some heat (exothermic).
    $2(CaSO_4 .\ 2H_2O)$ + heat—$2(CaSO_4 .\ 1/2\ H_2O) + 3H_2O$
    $2(CaSO_4\ .\ 1/2H_2O) + 3H_2O$—$2(CaSO_4\ .\ 2H_2O)$ + heat
  - Water resistant cast is prepared when melamine resin is mixed with plaster of Paris.
- Commonly available sizes—4 inch, 6 inch × 2.7 meter.
- *Factors affecting setting time:*
  - Temperature of water.
  - Manufacturers setting time.
  - Impurities in plaster.
  - Water condition (hard and soft)
  - Humidity.
  - Room temperature.
- *Uses of POP bandage:*
  - As a slab for immobilization.
    - Extent of slab coverage—50–70% circumference (2/3rd) of limb.
    - For upper limb—6–8 layers and for lower limb—10–12 layers
    - Volar surface in upper limb and dorsal surface in lower limb is preferred. Why? Molding is easier against

splint and also helps in reduction maintanance.
- *As definitive casting:*
  - Wrapped around whole circumference of limb or part involved.
  - The overlapping of bandage is 1/3rd–1/2 of previous turn.
  - Thickness of cast varies according to nature of fracture, limb type (upper or lower) and age of patient.
- Functional cast bracing.
- Deformity correction serial casting.
- Partial weight relieving orthosis.
- Spica.
- Charlney's traction unit.
- Pin plaster technique.

- *Complications with POP bandage:*
  - Neurovascular compromise.
  - Compartment syndrome.
  - Pressure sore.
  - Purulent dermatitis.
  - Reactionary edema.
  - Fracture disease.
  - Wasting of limb.
  - Joint stiffness.
  - Loss of reduction.

Fracture disease: It occurs as a result of prolonged immobilization of a fracture leading to:
• Pain
• Swelling
• Stiffness
• Osteopenia

- *Care of a limb in plaster:*
  - Constant movements of finger or toes.
  - Keep limb elevated.
  - Do not bring the plaster in contact with water.
  - Report immediately if any swelling, color changes, numbness or excess pain.

FIBERGLASS PLASTER (FIG. 1.2)

- *Characteristics:*
  - *Composition:* Fiber-glass impregnated with polyurethane polymer.
  - Colorful and sticky.

Fig. 1.2 Fiberglass plaster

Fig. 1.3 Stockinette

  - *Setting time:* 1–2 minutes.
  - Full strength of cast is achieved in 2–4 hours.
  - Activated by water or other agents.
- *Caution:* Surgical gloves must be worn before using this cast.
- Commonly available sizes 3" and 5" × 3.6 meter.
- *Advantages:* Light weight, water proof, lesser setting time.
- *Disadvantage:* Costlier.

STOCKINETTE (FIG. 1.3)

- *Characteristics:*
  - Continuous tubular cotton fabrics.
  - Water repellent property.
  - Stretchable that can accommodate various girth of limb.

- Extend it about 10 cm beyond each end of intended splint site.
- Commonly available in size 3"(upper limb) and 5"(lower limb) × 20 meters.
- *Uses:* Before application of slab and cast over limbs.
- *Advantages:* Prevention from skin complication like allergy, dermatitis, etc.

COTTON ROLL (FIG. 1.4)

- *Properties:*
  - 100% cotton and bleached to white.
  - High absorbent property.
  - Single and uniform lap without joints as thin long continuous layer.
- Available in standard 500 g but 100, 200, 300, 400 g also found.
- *Various uses like:*
  - For cleaning and swabbing of wounds.
  - For padding before applying slab and cast.
  - For wrapping around splints, etc.

COTTON ROLLER BANDAGE (FIG. 1.5)

- *Properties:*
  - 100% cotton fabrics with a loose open weave and bleached to white.
  - Quick absorbent property.
  - Number of holes per square centimeter of cotton gauze—4 × 4 = 16.
- Cotton roller bandages are commonly available in 4" and 6" × 4 meters.

- *Used for:*
  - For POP slab application.
  - For wrapping around various splints.
  - During wound dressing.
  - The most common fastening article in ward.
- *Starch impregnated roller bandages* becomes slimy when soaked in water and it becomes harder when dried. This property is utilized to provide extrastrength to POP slabs.
- *Why wet roller bandaging during POP slab application:*
  - Wet bandages increase POP setting time and provide enough time for plaster molding and limb manipulation. Wet bandages well incorporated with slab and provide extrastrength.
  - Dry bandages absorbs water from POP and decreases the setting time and side-by-side it does not incorporates well with slab.

PRINCIPLE OF REDUCTION AND CASTING

- For fracture reduction appropriate amount of traction and counter traction is applied in proper direction.
- Reduction is achieved by manipulation of distal fragment.
- A perfect reduction is said when all cortices are in contact at fracture site or reduction is said to be acceptable when both fragments have at least 50% contact both in AP and lateral views.

Fig. 1.4 Cotton roll

Fig. 1.5 Cotton roller bandage

- Even minimal rotation at fracture site is hardly accepted.
- Appropriate padding should be done around fractured limb especially over bony prominence.
- Reduced position of limb should maintain before, during and after casting.
- Any indentation during molding and wrinkles should be avoided during cast application.
- A reduced fracture is maintained in such a way that one joint above and one joint below is fully immobilized. But exceptions are Colles' fracture, fracture around ankle, etc.
- The position of limb should be maintained in functional position or position of immobilization. For most of the joint these two are the same but for wrist and hand these stands differently.
  - *Functional position:* The position in which limb can be maximally utilized even after its stiffness, e.g. glass holding position of wrist. This position is used for arthrodesis of a joint.
  - *Position of immobilization:* The position in which the ligaments and tendons around joints remains maximally stretched, so that the contracture of joint could be prevented, e.g. James position of hand (lumbrical plus hand posture).
- The fracture reduction and maintenance under cast also follows the "three-point molding principle of **Charnley's**". Out of these three points two point lies proximal and distal to fracture site. The third point lies at the site of fracture site but the direction of molding force working here is apposite to the above two points (Fig. 1.6).
- *Ask the patient to follow the instructions like:*
  - Keep the limb elevated. Why we ask the patient lying on bed with a cast in his either of the limb to keep over pillow or hang it with some cord or bandage? Just to maintain the limb above the patient heart level to ensure easy venous drainage and this act minimizes the swelling.

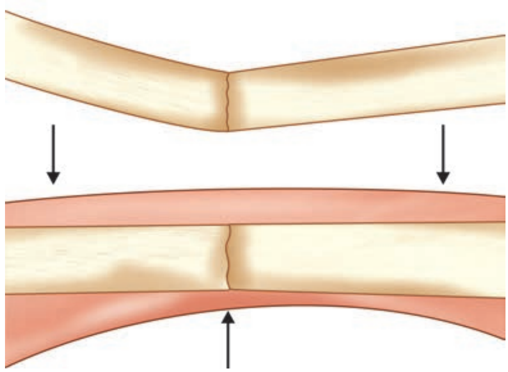

Fig. 1.6 Three-point molding principle of Charnley's

  - Ask the patient to do finger or toe movement—this improves the circulation in the respective limb and side-by-side keep the muscle active and finally minimize postcast stiffness.
  - Removal of cast is done immediately if any sign of cast tightness develops in the limb—like continuous pain, discoloration of finger, etc.

CASTING IN JAMES POSITION (RADIAL GUTTER, ULNAR GUTTER AND VOLAR SPLINTAGE WITH POP) (FIGS 1.7A TO C)

- *Position:*
  - *Wrist joint:* 30°–40° extension.
  - *Metacarpophalangeal joint:* 70° flexion.
  - *Proximal interphalangeal joint:* 20° flexion.
  - *Distal interphalangeal joint:* 10° flexion.
- *Extent:*
  - *Proximally:* Cover lower 2/3rd of forearm.
  - *Distally:* Proximal to distal interphalangeal joint.
- *Uses:*
  - Metacarpals fractures.
  - Proximal phalanx fracture of fingers.
  - Metacarpophalangeal joint injury
  - For preventing clawing.
  - After tendon repair and tendon transfer.

Fig. 1.7A Radial gutter in Jame's position

Fig. 1.8A Scaphoid cast

Fig. 1.7B Ulnar gutter in Jame's position

Fig. 1.8B Thumb spica

Fig. 1.7C Volar splint in Jame's position

SCAPHOID CAST AND THUMB SPICA (FIG. 1.8A)

- *Position:* Glass holding
  - *Wrist attitude:* Radially deviated and moderately dorsiflexed
  - *Thumb attitude:* Mild abduction.
- *Extent of cast:*
  - *Proximally:* Cover lower 2/3rd of forearm.
  - *Distally:* Up to proximal palmar crease and proximal to interphalangeal joint of thumb.
- *Uses:* Fracture scaphoid.

Fig. 1.9 Colle's cast

Fig. 1.10 U-cast

- *Thumb spica (1.8B):*
  - It maintains the wrist in 10°–20° of extension and thumb in slight flexion and palmar abduction.
  - It is used for immobilization of thumb in injuries around first carpometacarpal joint, metacarpophalangeal joint and interphalangeal joint.

COLLES' CAST (FIG. 1.9)

- *Position:*
  - *Wrist attitude:* Approx. 25° ulnar deviation with slight palmar flexion.
  - *Forearm attitude:* Full pronation.
- *Extent of cast:*
  - *Proximally:* Cover lower 2/3rd of forearm.
  - *Distally:* Proximal to palmar crease in volar aspect and just short of knuckle in dorsal aspect.
- *Used:*
  - For Colles' fracture.
  - For unstable fractures like fracture distal radius with ulna, intra-articular fracture or fracture dislocation; Colle's cast must extended above elbow.
- *For smith fracture:*
  - Full supinated forearm.
  - Ulnar deviation and dorsiflexion at wrist.
  - Extent of cast is above elbow.
- *For Barton fracture—Volar Barton:* Wrist-flexion attitude and in *Dorsal Barton*—wrist-extension attitude.

U-SLAB OR CAST (FIG. 1.10)

- *Position of limb:*
  - Arm by the side of trunk.
  - Elbow 90° flexion and pronated.
- *Extent of cast:*
  - Stretch form inside of arm
  - Run around the elbow
  - End over the junction of shoulder and neck.
- *Uses:* For fracture shaft of humerus.

☑ *Note:* Secure the upper most part of cast with some strapping or sling extending up to apposite shoulder or chest.

ABOVE ELBOW CAST (FIGS 1.11A TO C)

- *Position of limb:*
  - *Elbow:* 90° flexion
  - *Forearm:*
    - Fully supinated—for proximal 1/3rd fracture.
    - Midpronated—for middle 1/3rd fracture.
    - Full pronated—for distal 1/3rd fracture.
- *Extent of cast:*
  - *Proximally:* Up to midarm.
  - *Distally:* Just proximal to metacarpo-phalangeal joint of hand.
- *Uses:* For fracture both bone forearms.

Figs 1.11A to C Above elbow cast; (A) Supinated forearm; (B) Midprone forearm; (C) Pronated forearm

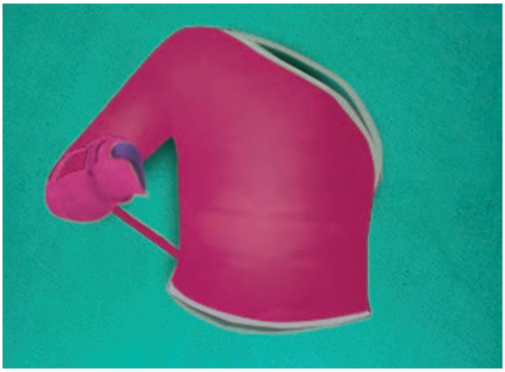

Fig. 1.12 Shoulder spica

SHOULDER SPICA (FIG. 1.12)

- It incorporates trunk with upper limb.
- *Position of limb:*
  - *Shoulder abducted:* In proximal humeral fractures, shoulder is abducted to such extent that maintain the alignment of distal fragment with proximal fragment.
  - Elbow 90° flexed and forearm in mid-prone position.
- *Extent of cast:*
  - Above the waist.
  - Involve ipsilateral shoulder.
  - Distal to metacarpophalangeal joint if needed otherwise restrict just proximal to wrist joint.
- There is supporting bar between forearm and trunk.
- *Used for:*
  - Brachial palsy
  - Selected cases of proximal humeral fracture dislocation.

BELOW KNEE CAST AND BOOT CAST (FIGS 1.13A AND B)

- *Position of limb:* Ankle slightly plantar flexed.
- *Extent of cast:*
  - *Proximally:* Just above calf bulk. Why?
    - To prevent sore around calf and cast edge interface.
    - To prevent hooping effect of calf muscle.
  - *Distally:* Pulp of toes must covered.
- *Used for:*
  - Fracture calcaneum and talus.
  - Fracture tarsals and metatarsal.
  - Sometimes for injury around ankle.

☑ *Note:* When cast extend below the bulk of calf it is called boot cast as it looks like the military boot.

CYLINDRICAL CAST (FIG. 1.14)

- *Position of limb:* Knee extension.
- *Extent of cast:* High groin to above ankle.

Fig. 1.13A Below knee cast

Fig. 1.13B Boot cast

Fig. 1.14 Cylindrical cast

Fig. 1.15 Above knee cast

- *Uses:*
  - Acute knee injuries.
  - Fracture patella.

ABOVE KNEE CAST (FIG. 1.15)

- *Position of limb:*
  - *Knee:* 15° flexion (why?)
    - To maintain functional position.
    - Flexed knee prevent rotation at fracture site.
  - *Ankle:* 10° plantar flexion in upper 1/3rd fracture and 20° plantar flexion in lower 2/3rds fracture. Why? It prevents posterior angulation at fracture site.
- *Extent:* Midthigh to short of metatarsophalangeal joint.
- *Uses:*
  - For fracture and fracture-dislocation around knee.
  - For fracture tibia and fibulae.
  - For tibial plafond fracture.

CTEV CAST A SPECIAL TYPE OF ABOVE KNEE CAST (FIG. 1.16)

- Ponseti technique of serial casting for congenital talipes equinovarus (CTEV) correction.
- *Position of limb:*
  - *Knee:* 90° flexion (why?)
    - Prevents slippage of cast.
    - Relaxes gastrocnemius muscle.
    - Prevents tibial rotation.

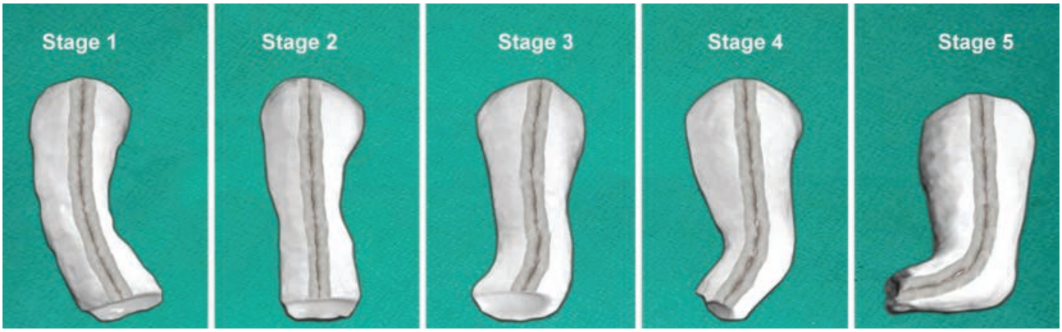

Fig. 1.16 CTEV cast a special type of AK cast

- *Ankle and foot:* As per sequence of deformity correction in serial casting:
  - First midfoot cavus and forefoot pronation.
  - Then forefoot adduction and heel varus and equinus.
  - Finally residual equinus if any.

Extent of Cast

- *Proximally:* Just short of groin.
- *Distally:* Cast is applied in such a way that pulp of toes are covered and dorsum of toes visible.

Fig. 1.17 PTB cast—a functional cast bracing

PTB CAST—A FUNCTIONAL CAST BRACING: (A SARMIENTO 1963) (FIG. 1.17)

- It is a closed method of fracture treatment which is complimentary to other methods of fracture management.
- *Principle:* It is based on the belief that continuing function while a fracture is uniting it does three things:
  - Enhances oteosynthesis.
  - Promotes healing of fracture.
  - Prevent complication like joint stiffness.
- *Mechanism of action* **Pascal's law**:
  - When the limb is loaded there is generation of intracompartmental pressure around fracture site that exerts pressure on wall of facial compartment.
  - As there is a rigid cast around limb, the similar amount of pressure starts working in opposite direction that maintain the reduction of fracture.
- *Prerequisites for patellar tendon bearing (PTB) casting:*
  - Fracture should be treated first by some conventional methods.
  - Angular and rotational deformity must be corrected.
  - There is no pain at fracture site on minimal movements.
  - There is no deformity at fracture site.
  - There should be a reasonable resistance to telescopy.
  - Shortening should not exceed 0.25" for tibia and 0.5" for femur.
- *Used for:*
  - Fracture distal femur.
  - Fracture proximal tibia.
  - Fracture distal tibia.
  - Fracture shaft of humerus.

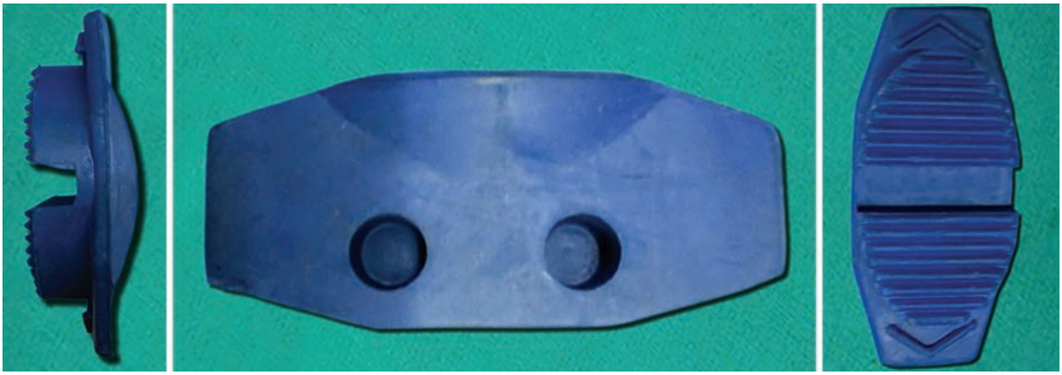

Fig. 1.18 Walking heel (Rubber)
(*Courtesy:* Dr Kumar Kaushik)

- *Contraindications:*
  - Noncompliant patient.
  - Neuromuscular disorder.
  - Altered sensitivity of limb.
  - Isolated tibia fracture (fibula intact).
  - Proximal femur fracture.
  - Both bone forearms fracture.
  - Monteggia fracture dislocation.
  - Galeazi fracture dislocation.

WALKING HEEL (RUBBER) (FIG. 1.18)

- *Parts of walking heel:*
  - Thin peripheral extension.
  - Two ribbed thickened broad base.
  - Transverse slot in heel.
  - Elevated rounded medial ridge for medial arch.
  - Hole on lateral side to make it lighter.
- *Use:* In PTB cast. Why? It prevents breakage of plaster cast during weight bearing.

WALKING IRON (FIG. 1.19)

- *Parts of walking iron:*
  - Metal cross bar.
  - Metal upright.
  - Flare (rounded) of side bar.
  - Terminal part of side bar.
  - Rubber heel.
- *How to apply:*
  - 2.5 cm below neck of fibulae.

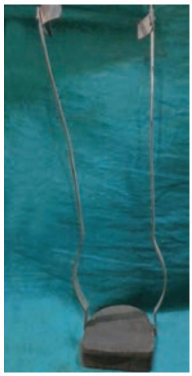

Fig. 1.19 Walking iron
(*Courtesy:* Dr Kumar Kaushik)

  - Rubber heel corresponds to center of sole.
- *How to apply:*
  - Below knee padding of limb and apply one or two POP bandages over it.
  - Set the walking iron.
  - Further wrapping of walking iron with POP bandages.
- *Uses:* As weight-relieving orthosis
  - Fracture tarsal, metatarsals.
  - Fracture calcaneum, talus.

PIN PLASTER TECHNIQUE (FIG. 1.20)

- *Principle:* Stabilization of fracture with cast and Steinmann pin assembly.

- *How to apply:*
  - 1st pin above fracture and 2nd below fracture, as far as possible.
  - Achieve reduction.

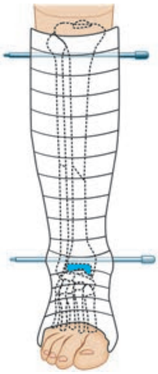

Fig. 1.20 Pin plaster technique

  - Cast applied in reduced position.
  - Minimal joint involvement.
- *Advantages of pin plaster technique:*
  - Prevents joint stiffness.
  - Early mobilization.
  - Check rotation.
- *Disadvantages of pin plaster technique:*
  - Loss of reduction.
  - Pin track infection.

HIP SPICA (FIGS 1.21A TO D)

- It encompasses trunk with the lower limb.
- *Position of limb:*
  - *Hip:* 45° flexion and slight abduction. Why abduction? To clear the perineum and maintain hygiene.
  - *Knee:* 45° flexion. Why so? Flexion less than 45° may lead to loss of fracture reduction.

Figs 1.21A to D Hip spica. (A) Single hip spica; (B) Types of hip spica; (C) One and half spica; (D) Hip spica in human position for developmental dysplasia of the hip (DDH)

- *Ankle:* Neutral position.
- *Extent of cast:*
  - Proximally—extend up to nipple and rest on rib cage. Why? It provides a bony support to the cast and prevent its breakage.
  - *Distally:* On the basis of distal extension of cast; spica can be classified as follows:
    - *Single hip spica:* Involving only one leg and extend up to foot.
    - *One and half spica:* Involves one leg up to foot and other leg up to knee.
    - *Double hip spica:* Involving both leg up to foot.
- *Uses:*
  - Fracture femur in children.
  - After pediatric hip surgeries.
- *Strengthening of spica:*
  - By applying POP slabs around hip and thigh.
  - By wrapping wooden stick with POP bandages between both legs.
- Why we apply soft material between abdomen and cotton padding during spica application?
  - To create a space between abdomen and spica cast; that can adjust the belly of the patient during respiratory movement.
  - To prevent complications mentioned below:
- *Complications:*
  - Urinary retention.
  - Plaster cast syndrome (PCS)—A constellation of symptoms—like pernicious vomiting, pain abdomen, abdominal distension; developed soon or later after application of spica is called plaster cast syndrome.

    The underlying pathology is obstruction of 3rd part of duodenum in between aorta and superior mesenteric artery. Treatment given are:
    - Immediate removal of spica.
    - Stop oral intake.
    - Intravenous fluid infusion.
    - Antiemetics.
    - Antacids.
    - Gastric decompression by naso-gastric tube.
    - Serum electrolyte monitoring.
    - Severe cases laparotomy. PCS were common in the past when scoliosis were corrected with Harrington rod.
- *Immediate hip spica application:*
  - *Indication:* Fracture shaft of femur in children <5–6 years age with shortening less than 2 cm.
  - *Complications:*
    - Compartment syndrome.
    - Loss of reduction.
    - Angulation.
    - Shortening.
  - To reduce the rate of complication, the 90°–90° position of hip and knee is used but it can be applied only for age less than 2–3 years due to fear of neurologic complication.

☑ *Note:* Normally hip spica is applied after keeping the pediatric fracture shaft femur under 3 week of skin traction (<5 years) or skeletal traction (>5 years) because during these period acceptable reduction is achieved and fracture becomes sticky also. By this way, above complication can also be minimized.

- *Hip spica in human position for developmental dysplasia of the hip (DDH):*
  - *Position:* 95° flexion at hip joint and 40°–45° abduction at hip joint.
  - *Advantages of human position:*
    - Stability at hip
    - Decreased risk of osteonecrosis of head of femur.

WEDGING OF CAST (FIG. 1.22)

- *How much correction by wedging:* Only 10°–15° angulation should be corrected by wedging.
- *Timing of wedging:* Wedging should be done as soon as possible (2–3 days). Once the fracture becomes sticky; it prevents the lateral motion at fracture site.

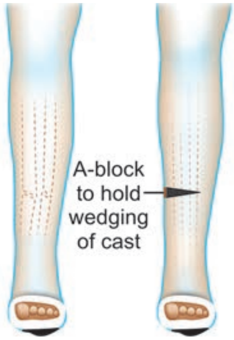

Fig. 1.22 Wedging of cast

Fig. 1.23 Making a window in cast

- *How wedging is done:* 5 steps—

Identification of the site of wedging
↓
Do circumferential slitting of cast just opposite to the site of angulation
↓
At least ¼th of circumference of cast should be left
↓
Hold the wedging of cast with a block and repair the cast with POP bandage.
↓
Final reduction is checked under X-ray.

MAKING A WINDOW IN CAST (FIG. 1.23)

- *Timing of making window:* When plaster becomes fully dried.
- *Indications:*
  - For frequent inspection of wound.
  - For stich removal.
- *Identification of window making site:*
  - By over padding to produce bulging at window site.
  - By measuring the wound site from fixed bony point.
- *How window is made:*

Apply plaster cutting saw on marked area
↓
Elevate the window into to from the cast

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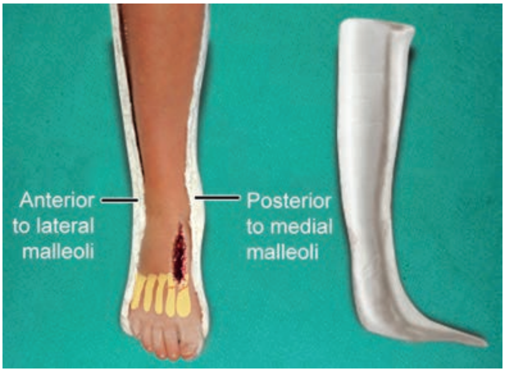


Fig. 1.24 Bivalving of cast

Contd...

↓
Remove the underlying padding
↓
Inspect the wound
↓
Replace the padding and keep the window in place
↓
Apply cotton bandage over window or repair with POP bandage

BIVALVING OF CAST (FIG. 1.24)

- A method of cast removal when whole cast is removed in two parts.
- *When to do bivalving:*

- – If there is need of frequent observation of fracture site, e.g. in cases compound fractures.
- – Where there is risk of compartment syndrome.
- – For removal of fiberglass cast.
- For example, in case of below knee cast; cut the cast posterior to medial malleoli in medial side and anterior to lateral malleoli in lateral side in vertical plane.

Fig. 1.25 Slitting of cast

SLITTING OF CAST (FIG. 1.25)

- *Indication of slitting of cast:* When a POP cast applied over a limb shows any one of the following features as:
  - – Appearance of swelling in distal part of limb, e.g. toes.
  - – Pain in limb.
  - – Diminished distal pulsation.
  - – Compromised capillary refilling.
  - – Paleness in distal part of limb.
  - – Paresthesia of limb.
- *How to slit a cast:*

Make a marking of slitting overt cast.

↓

With the help of electric or manual saw a straight cut is made in long-axis of limb.

↓

Slit directly up to underlying padding of cast and remove the cotton paddings, so that limb could be directly visible.

Contd...

Contd...

↓

Now apply a bandage around slitted cast to just keep it in place, i.e. here POP cast is acting as splint only.

CHECKLIST FOR CASTING

- Extent of cast.
- Position of limb.
- Alignment of limb.
- Smoothness/irregularity of cast.
- Cracks over cast.
- Any sign of tight plaster.

CHAPTER

2

Dressing Materials

Every orthopedician gives a smile when he/she looks a dry or red wound. Because infection is just a complication for else, but it might be disastrous in orthopedics. For this the surgeon develops the skill of wound dressing. But the knowledge about different dressing's materials are also needed to perform their best.

OBJECTIVE OF DRESSING

- It controls the moisture content of wound.
- It protects the wound from infection.
- It enhances the process of slough removal.
- It maintains the optimum pH of wound.
- It maintains the optimum local temperature, so that wound can heal as soon as possible.

LAYERS OF DRESSING (FIG. 2.1)

- *Contact layer:* After applying dressing chemicals over wound, cotton gauze pieces are kept directly over the wound.
- *Absorptive layer:* Dressing pads having absorbent property are kept in this layer. This is the thickest layer.
- *Compressive layer:* Here cotton roller bandages or elastic bandages are applied to keep the underlying layers in place.

COTTON GAUZE PIECES (FIG. 2.2)

- *Properties:*
  - 100% cotton fabrics with a loose open weave.

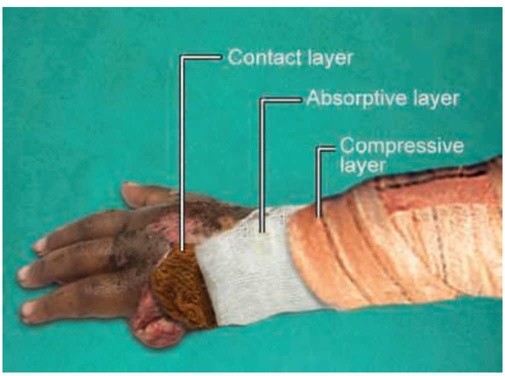


Fig. 2.1 Layers of dressing

Fig. 2.2 Cotton gauze pieces

Fig. 2.3 Gamjee roll and dressing pad

Fig. 2.4 Elastic bandage (Crepe bandage)

  - Bleached to white.
  - Quick absorbent property.
  - Prepared in long sheets.
  - Number of hole per square centimeter of cotton gauze—4 × 4 = 16.
- Gauge pieces are prepared in various sizes according to requirement, but commonly used sizes are 5 cm × 5 cm, 7.5 cm × 7.5 cm, 10 cm × 10 cm.
- Used for wound dressing, surgical site preparation, etc.

GAMJEE ROLL AND DRESSING PAD (FIG. 2.3)

- Invented by *Dr Joseph Sampson Gamjee.*
- *Characteristics:*
  - It has a long thick layer of absorbent cotton sheet between two layers of absorbent cotton gauze.
  - High absorbent property.
  - Promote quick healing of wound.
  - Skin friendly.
- *Use:* After dressing of wound it is wrapped around it as bandage.
- How dressing pads are prepared? A thick layer of cotton sheet is kept between two layers of cotton gauges and required sizes (most commonly 5 cm × 5 cm, 7.5 cm × 7.5 cm, 10 cm × 10 cm) of dressing pads are cut from it.

ELASTIC BANDAGE (CREPE BANDAGE) (FIG. 2.4)

- *Composition:* Cotton, polyester and elastic yarns.
- *Functions:*
  - The bandage create even stable pressure around area of application leading to reduction of blood flow and thus reduces the swelling around injured area.
  - Hemostatic effect due to compression.
- *Uses:*
  - For strapping of sprain and strain around joints.
  - For splinting of fractures.
  - For postoperative compressive bandages.

ADHESIVE SURGICAL TAPE (FIGS 2.5A TO C)

- *Two types:*
  1. Cotton tape (Leucoplast)
  2. Paper tape (Micropore)
- Zink oxide (white color) is adhesive material.
- Breathable tapes allow air to reach skin.
- Elastic or stretchable tapes are also available (Dynaplast/Elastoplast).
- *Uses:*
  - It holds the dressing or bandages over wounds.
  - Strapping around joints.

Figs 2.5A to C Adhesive surgical tape

☑ *Note:* Sterile adhesive dressing pads are also available (Primapore).

TINCTURE BENZOIN (FIG. 2.6)

- *Composition:* Benzoin resin in alcohol.
- *Effect:* Adhesive and antiseptic.
- *Uses:*
  - Before application of cotton during casting especially in infants and children.
  - Before skin traction application.
  - Before application of tourniquet.

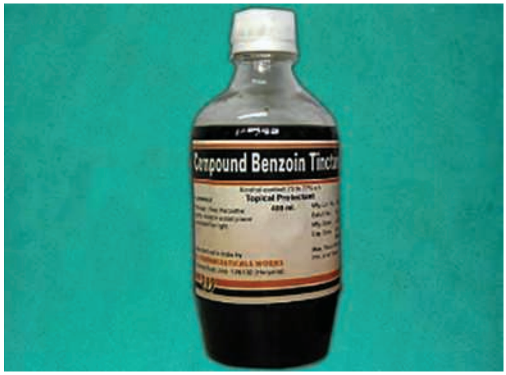


Fig. 2.6 Tincture benzoin

  - As wound sealant after dressing of pin tract infection.
  - It can be applied to minor cuts.
  - Act as oral mucosal protectant.

MAGNESIUM SULFATE CREAM (MAGSULF/SUMAG) (FIG. 2.7)

- *Chief composition:*
  - Sumag (Magnesium sulfate and urea).
  - Magsulf (Magnesium sulfate and glycerin).
- *Effect:* Hygroscopic.
- Reduces edema.

PARAFFIN GAUZE (JELONET/ SOFRA-TULLE) (FIG. 2.8)

- *Two types:*
  1. *Plain:* Without any impregnated antibiotic.
  2. Antibiotic impregnated—framycetine, betadine, 0.5% chlorhexidine acetate, neomycin, polymyxin, nitrofurazone, etc.
- *Functions:*
  - Keeps wound moist.
  - Prevent adhesion of dressing with wound.
  - Antiseptic property.
  - Promote in granulation tissue formation.

Fig. 2.7 Magnesium sulfate cream: (Sumag and Magsulf)

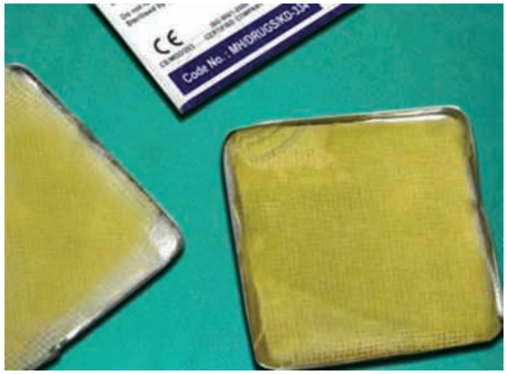


Fig. 2.8 Paraffin gauze: (Jelonet/Sofra-Tulle)

- *Uses:*
  - On granulating wounds.
  - In skin grafting (donor or recipient site).
  - Over burn wounds.

ALGINATES (ALGISITE-M) (FIG. 2.9)

- *Composition:* Sodium and calcium salt of alginic acid and naturally found in brown Algae.
- *Action:* Biofilm formation leading to—
  - Absorbent property.
  - Hemostatic property.
  - Keep surrounding environment moist.
- *Uses:* For dressing of wound with large amount of exudates, chronic ulcers, burn wounds, skin grafting sites and surgical wounds.

Fig. 2.9 Alginates (Algisite-M)

HYDROCOLLOIDS (DUODERM) (FIG. 2.10)

- *Composition:* A layer of gelatin, pectin and carboxymethylcellulose under cover of adhesive sealant-like polyurethane.
- *Function:* The polysaccharides material when comes in contact of wound exudates; polymers absorbs water and forms gel which is immobile. This moist condition promote fibrinolysis, angiogenesis and wound healing.
- *Uses:* For dressing of clean wounds, bed-sores, venous ulcers, superficial to deep burns and eczema.

Fig. 2.10 Hydrocolloids (Duoderm)

HYDROGEN PEROXIDE (H_2O_2) (FIG. 2.11)

- *Composition:* 20 volumes H_2O_2, i.e. 1 volume of 20 volume H_2O_2 produces 20 volume nascent oxygen.
- *Effect:* Cleansing.
- *Uses:*
  - Frothing brings debris out of wound.
  - Destroy anerobic organism.
  - Used for chemical cauterization.
  - Removes blood stain from clothes.

Fig. 2.11 Hydrogen peroxide (H_2O_2)

SAVLON (TARTRAZINE YELLOW COLOR) (FIG. 2.12)

- *Composition:*
  - *Strong cetrimide:* 16% (w/v).
  - *Chlorhexidine gluconate:* 7.5 (v/v).
  - *Isopropyl alcohol:* 6.8% (v/v).
- *Effects:* Cleansing and disinfectant
- *Uses:*
  - 1:30 dilution (35 mL of savlon in 1 L of water) for cleansing and disinfection of dirty wounds.
  - 1:100 dilution (100 mL of savlon in 1 L) for operative site scrubing, storage of thermometer, etc.

Fig. 2.12 Savlon

DETTOL (LIGHT YELLOW COLOR) (FIG. 2.13)

- Dettol produces a milky emulsion of oil droplets when diluted with water.
- *Composition:* 4.8% chloroxylenol and terpineol.
- *Effects:* Antiseptic and disinfectant.
- *Uses:*
  - Used to clean minor cuts, wound, etc.
  - For cleaning of house hold surfaces, walls of slaughter houses, etc.

Fig. 2.13 Dettol

SURGICAL SPIRIT (FIG. 2.14)

- *Composition:* 70% alcohol (isopropyl alcohol or ethanol).
- *Effect:* Antiseptic.
- *Uses:*
  - For cleaning of infection site.
  - For cleaning of stitched wound during wound dressing.

Fig. 2.14 Surgical spirit

Fig. 2.15 Povidone Iodine

- For dry dressing.
- For removal of betadine paint during surgical site preparation.

☑ *Note:* The natural alcohol is colorless. Its blue color is due to various color additives that prevents the alcohol abuse.

POVIDONE IODINE (FIG. 2.15)

- Solution—(5% and 10%), Scrub—7.5%, Ointment—10%.
- Previous form—Iodine.
- Present form—Iodine + polyvinyl pyrrolidone = Polyvinyl pyrrolidone iodine (PVI) or povidone iodine.
- *Effects:* Antiseptic and effective against bacteria, fungi, protozoa, virus and yeast.
- *Disadvantages of iodine:*
  - Insolubility and instability.
  - Irritant property.
  - Staining property.
- *Advantages of PVI:* Bactericidal activity without its toxic effects.
- *Uses and available form:*
  - Solution (5% and 10%)—surgical site preparation.
  - Scrub (7.5%)—surgical hand scrubbing
  - Ointment (10%)—for superficial wound.

CHLORHEXIDINE SOLUTION (FIG. 2.16)

- *Chief constituent:* Chlorhexidine gluconate.

Fig. 2.16 Chlorhexidine solution

- *Effects:*
  - Antiseptic in lower concentration.
  - Bactericidal in higher concentration.
- *Uses:*
  - For surgical hand scrub.
  - For hand washing by healthcare personnel.
  - Postoperative wound cleaning.
- *Commonly available form:* 2% and 4%.

EDINBURGH UNIVERSITY SOLUTION OF LIME (EUSOL) (FIGS 2.17A AND B)

- *Composition (Acidic pH):*
  - *Boric acid:* 1.25 g.
  - *Bleaching powder ($CaOCl_2$):* 1.25 g.
  - *Sterile water:* 100 mL.

- Mechanism— release of nascent chloride.
- Effects—desloughing agent.
- *Uses:*
  - To separate slough from infected wounds, bed sores, ulcers and burns.
  - Useful for dressing of wounds infected with *Pseudomonas* due to its acidic pH.

☑ *Note:* If Eusol is prepared in ward, the fresh preparation is needed daily. You know, what we have is Eusol-I. There is also Eusol II containing sodium acetate and glacial acetic acid.

Vinegar (acetic acid, ascorbic acid, citric acid and tartaric acid) is also used as desloughing agent specially in cases of *Pseudomonas* infection.

Figs 2.17A and B (A) Edinburgh University solution of lime (EUSOL); (B) Vinegar

OXOFERIN SOLUTION (FIG. 2.18)

- *Chief composition:* Tetrachlorodecaoxide.
- *Mechanism of action:* Release nascent oxygen which is immunemodulator, mitogenic, chemotactic, accelerator of phagocytosis.
- *Effect:* Cleansing action
- *Use:* For infected and contaminated wounds.

☑ *Note:* 1% sodium hypochlorite solution (**Daikin** solution) is comparable to oxoferin solution.

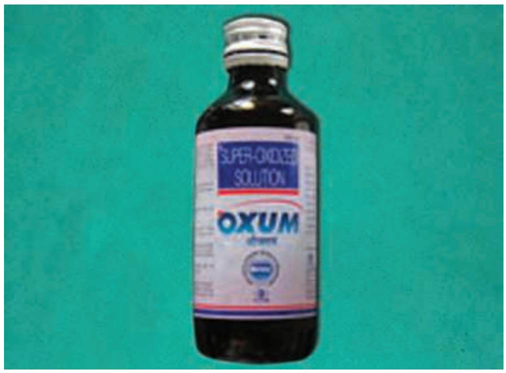


Fig. 2.18 Oxoferin solution

SILVER IONS SOLUTION (QURION) (FIG. 2.19)

- *Chief component:* Silver ions (0.01% silver nitrate).
- *Effect:*
  - Kills bacteria.
  - Destroy biofilm.
  - Stimulate growth of granulation tissue.
- *Use:* For infected and contaminated wounds.

Fig. 2.19 Silver ions solution (Qurion)

PLACENTA EXTRACT (PLACENTREX) (FIG. 2.20)

- *Chief source:* Human placenta.
- *Effect:*
  - Anti-inflammatory

- Antiageing.
- Improve blood circulation.
- Increases hormone level.
- Encouraging new cell production.

• *Uses:* For chronic and nonhealing wound.

COLLAGEN GRANULES AND COLLAGEN SHEET (COLLAWOUND) (FIG. 2.21)

• *Chief component:* Collagen protein (types I, II, III)

• *Effect:*
  - Inhibit matrix metalloproteinases (MMPs) that promote extracellular matrix (ECM) and granulation tissue formation.
  - Chemotactic effect
  - Absorbs wound exudates and maintain moist environment.

• *Use:* For chronic and nonhealing wound.

ANTIBIOTIC OF TOPICAL USE

• *Commonly used antibiotics are:*
  - Framycetin sulfate (Soframycin)
  - Neomycin + polymyxin + bacitracin (Neosporin)
  - Fusidic acid (Fucidin)
  - Metronidazole (Metrozyl)
  - Silver sulfadiazine (Silvrex).

DRESSING TROLLEY (FIG. 2.22)

• *Total number of dressing trolley in ward:* Two; one for clean wound and other for infected wound.

• *Materials kept over dressing trolley:*
  - *Surgical drum with sterile:* Gauze pieces, dressing pads, cotton rolls roller bandage.
  - *Cidex-tray with:* Scissor, artery forceps, needle holder, thumb-forceps.
  - *Kidney-tray:* Concavity of tray confines the curvature of body part.
  - *Transparent glass bottle with* **Cheatle's forceps***:*

Fig. 2.20 Placenta extract (Placentrex)

Fig. 2.21 Collagen granules and collagen sheet (Collawound)

Fig. 2.22 Dressing trolley

- Wide mouth bottle.
- Transparent.
- Sterile cotton at base of bottle.
- Savlon solution (savlon contain cetrimide which is a culture media for *Pseudomonas* hence its use is controversial).
- Capacity 1 pound.

– *Other dressing materials:* Cotton roll, cotton roll bandage, adhesive tape, surgical gloves, surgical blades; normal saline bottles, hydrogen peroxide, savlon sol, surgical-spirit, betadine, eusol, oxoferine solution, magsulf cream, etc.

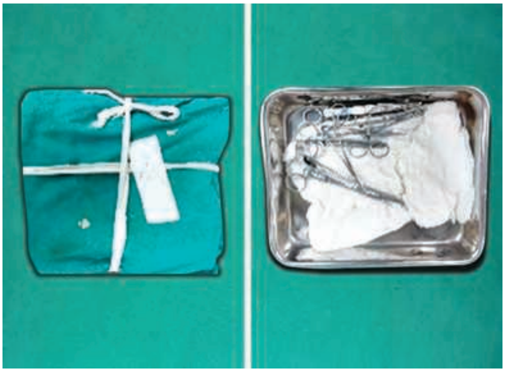


Fig. 2.23 Cut open tray

CUT OPEN TRAY (FIG. 2.23)

- *It contains:* B-P (Bard-parker) blade handle, artery forceps, thumb forceps, needle holder, scissor, suture materials, cotton gauze, cotton pad.
- Sterilized by autoclaving.

Fig. 2.24 Cidex-tray

CIDEX-TRAY (FIG. 2.24)

- It contains 2% glutaraldehyde solution.
- Change the solution in every 14 days.
- Used for sterilization of sharp instrument like scissor.

PUS CULTURE TUBE (FIG. 2.25)

- *Two components:*
  1. Sterile cotton swab.
  2. Sterile tube.
- *Sample collection:* From all parts of wound with help of sterile cotton swab for both dead and live organism. Swab should not touch the adjacent normal skin otherwise sample would be contaminated from normal flora of skin.
- *Culture method:* Sample is spread over different types of culture plates and plates are kept in incubator for 24–48 hours.
- *Antibiotic sensitivity:* Visible colonies obtained from incubator are tested against different antibiotics to determine which

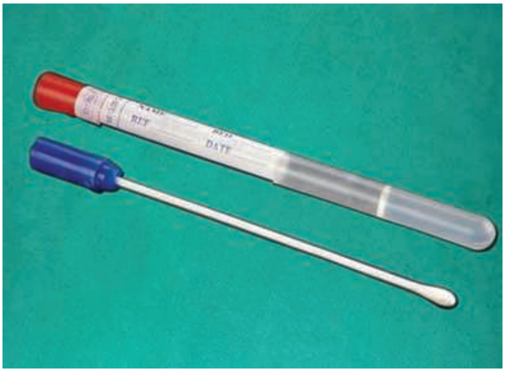


Fig. 2.25 Pus culture tube

will treat the infection by killing the micro-organism.

- *Why wound culture and sensitivity:*
  - To choose proper antibiotic for infection.
  - To prevent antibiotic resistance due to overuse of drugs.
- *What should we do before coming of testing report:*
  - Use broad spectrum antibiotic.
  - Use group of antibiotics covering all three gram+ve, gram-ve and anaerobic organism.

CHAPTER

3

Orthopedic Strappings, Bandages and Slings

Proper immobilization of the affected part is of utmost significance in orthopedics. One can maintain the reduction even by a simplest ways like elastic bandages or adhesives.

FINGER AND TOES STRAPPING (BUDDY TAPING) (FIGS 3.1A AND B)

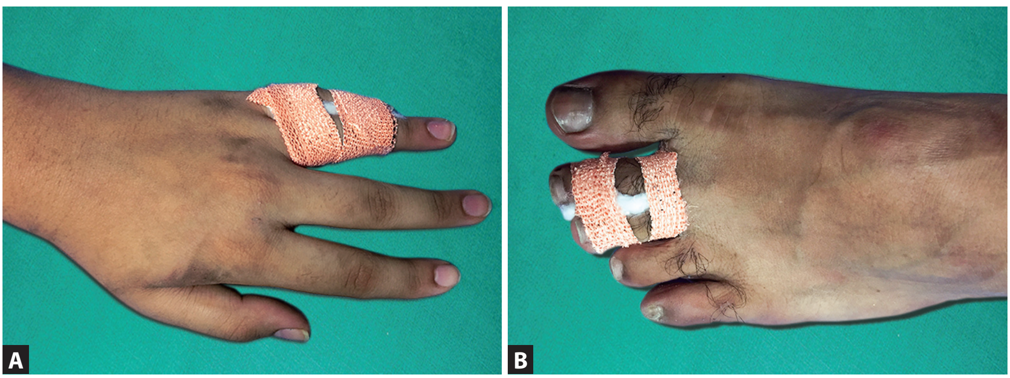
- Strapping of injured finger along with healthy adjacent finger.
- *Indications:*
  - Distal interphalangeal joint fracture-dislocations of hand and foot.
  - Middle and distal phalangeal injuries.

ARM CHEST STRAPPING (VELPEAU) (FIGS 3.2A AND B)

- Strapping of affected arm along with chest.
- *Indications:*
  - After reduction of shoulder dislocation.
  - For any traumatic condition around shoulder and arm.

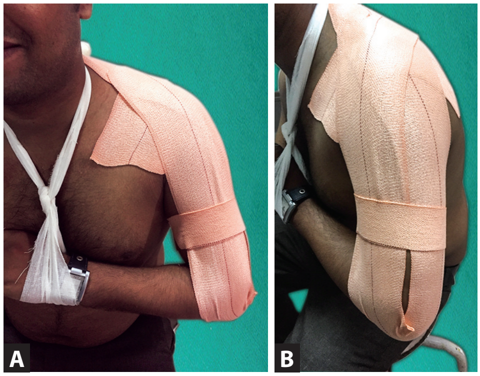
JONES STRAPPING (FIGS 3.3A AND B)

- The first strip starts from superior aspect of shoulder, running along outer surface



Figs 3.1A and B Finger and toes strapping (buddy taping)

Figs 3.2A and B Arm chest strapping (valpeau)



Figs 3.3A and B Jone's strapping. (A) Front view; (B) Side view

of arm and turn around elbow. The second strip starting from anterior axillary fold, reaching to top of shoulder and ends at posterior axillary fold.

- *Indications:*
  - Fracture Lateral end clavicle.
  - Acromioclavicular joint disruption.

CHEST STRAPPING (FIG. 3.4)

- Two vertical straps on either side of painful area and one horizontal strap along the painful rib.
- *Indication:* Fracture rib.

Fig. 3.4 Chest strapping

BANDAGING AROUND ANKLE AND WRIST (FIGS 3.5A AND B)

- It partially immobilizes the ankle and wrist joint and also reduces swelling due to its compression effect.
- *Indication:* For ankle sprain and wrist sprain.

ROBERT JONES BANDAGE (FIG. 3.6)

- This bandaging technique was developed by Sir Robert Jones during Ist world war for temporary immobilization of injure extremities.

Figs 3.5A and B Bandaging around wrist and ankle

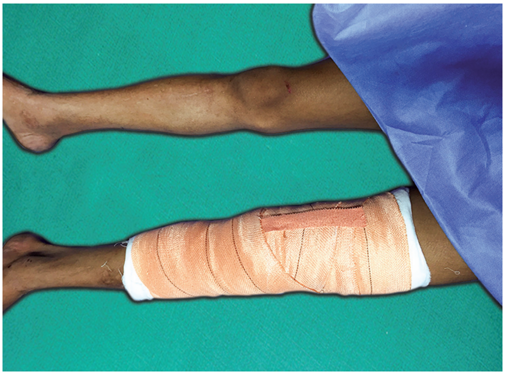


Fig. 3.6 Robert Jones bandage

- This is basically a multiple layer compression bandage applied around a injured limb or joint.
- How it acts?
  - It provides a splintage to injured limb.
  - It reduces bleeding.
  - It minimize swelling.
- How to apply?
  - A wooden or plastic splint is kept around injured bone especially in fracture cases.
  - A several layers (commonly three) of cotton that alternates with roller bandage or elastic bandage is applied in compression mode.
- *Used:*
  - For traumatic bone and joint injuries.
  - As postoperative compressive bandage.

Figs 3.7A and B Figure of 8 bandage. (A) Front view; (B) Back view

FIGURE OF 8 BANDAGE (FIGS 3.7A AND B)

- This bandage look like a numeric digit ‚8 hence it is called figure of 8 bandage.
- How to apply?
  - Patient is asked to sit over a stool.
  - Ask the patient to retract both shoulders behind as military man position.
  - A gamgee pad or cotton roll is wrapped around both shoulders.
  - Pad is fastened with roller bandage in figure 8 fashion to keep the pad in place.
- *Its another variant called ring bandage:*
  - Here a layer of cotton is sandwiched between two strips of roller bandage of appropriate size.
  - Each bundle is placed around shoulder and fastened in the middle of upper back.
- *Used:* For fracture clavicle.

BALL BANDAGING (FIG. 3.8)

- It reduces and immobilizes the fracture against some hard spherical object (like

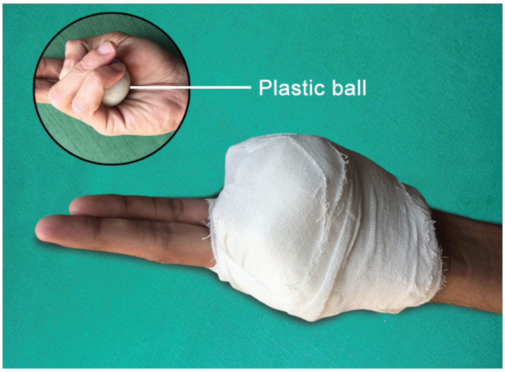


Fig. 3.8 Ball bandaging

Fig. 3.9A Triangular sling

small ball) kept in affected palm and secured with roller bandage.

- *Indications:*
  - Metacarpal fractures
  - Sometimes phalangeal fracture and dislocation except distal phalanx.

SLING IN ORTHOPEDICS

- *Definition:* A bandage or fabrics that supports the part of upper limb with neck is called sling.
- Various forms of slings are

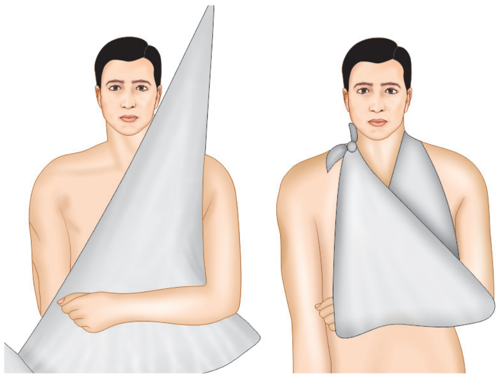


Fig. 3.9B Triangular sling: How it is applied

Triangular Sling (Figs 3.9A and B)

- It is a triangular piece of cotton fabrics that hold the forearm with neck. Sometimes a broad sheet of fabrics (Swathe) is also used to secure the arm with chest.
- *Used:*
  - Supporting the upper limb in cases of injury around shoulder, arm, elbow and forearm.
  - Suspension of upper limb in post operative cases.

Sling (Short) versus Cuff and Collar Sling (Figs 3.10A and B)

☑ *Note:* Why we avoid the use of shorter sling in fracture humerus but cuff and collar sling is preferred? Sling elevates the elbow

Figs 3.10A and B (A) Short sling; (B) Cuff and collar sling

Comparison between sling (short) and cuff and collar sling		
	Sling (short)	*Cuff and collar sling*
Definition	Here a bandage is fastened around wrist and hanged with neck	Here bandage or fabric is used to make a cuff around wrist and hanged in the neck
Elbow and forearm position	It makes the elbow acutely flexed and keep the wrist and hand nearer to neck	It maintains the elbow in 90° of flexion
Function	It elevates the elbow and shoulder higher	It promotes the gravitational pull working over elbow and distal fracture segment of humerus
Use	For fracture clavicle and acromioclavicular joint disruption	For fracture shaft of humerus

and applies a vertical compression force in direction of humerus and shoulder. Thus, it causes overriding and lateral angulation at fracture site. To overcome this issue cuff and collar sling is applied that maintain the elbow in 90° flexion and promote the gravitational pull working over elbow and distal fracture segment. This pull generate a traction force against shoulder that reduces the fracture.

Broad Arm Sling or Arm Pouch Sling (Fig. 3.11)

- This is a bag made-up of soft fabrics and attached with straps and belt.
- *Used:*
  - Supporting the upper limb in cases of injury around shoulder, arm, elbow and forearm.

Fig. 3.11 Broad arm sling or arm pouch sling

  - Suspension of upper limb in post-operative cases.

CHAPTER

4

Orthopedic Tractions and their Equipment

Various types of traction can be seen in orthopedic wards. They may act as a temporary immobilizer or as a definitive method of treatment. It may be surface type or invasive, it may be very simple to complex one.

CRAMER'S WIRE (LADDER SPLINT) (FIG. 4.1)

- These are ladder like splints made-up of metallic wires.
- *Use:* Temporary immobilization during transportation.

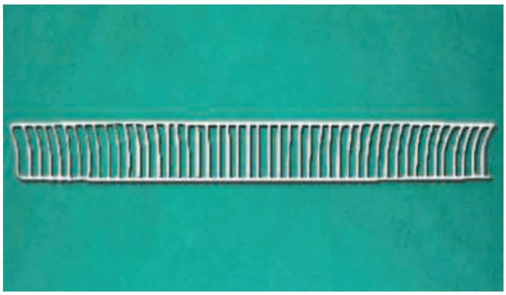
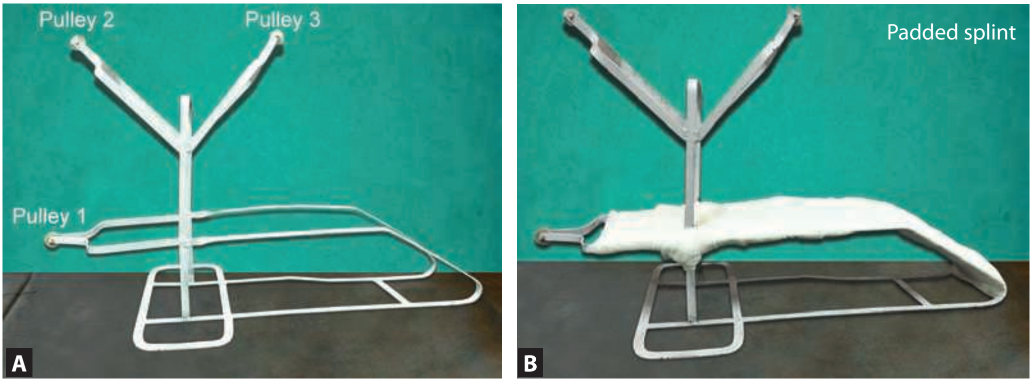


Fig. 4.1 Cramer's wire (ladder splint)

BOHLER BRAUN SPLINT (BOHLER AUSTRIAN SURGEON) (FIGS 4.2A AND B)

- Designed by **Braun**, modified by **Bohler**.
  - Only one lower most pulley was there in Braun's design.
  - Bohler added two more pulley.
  - *Four pulley sets also available.*
- *Uses of pulleys:*
  - 1st pulley in the line of leg—for calcaneum and distal tibial traction.
  - 2nd pulley
    - In line of supracondylar area of femur—for upper tibial traction.
    - In the line of femur shaft—for distal femoral traction.
  - 3rd pulley—to change the angle of traction and prevent equinus deformity at ankle.
- *Advantages:*
  - Changing the angle of traction as required.
  - Multiple traction can be given simultaneously.

☑ *Note:* In four pulley sets, the function of 2nd pulley is separately done by two pulley, i.e.
  - 1st pulley in the line of leg—for calcaneum and distal tibial traction.
  - 2nd pulley in the line of supracondylar area of femur—for upper tibial traction.
  - 3rd pulley in the line of femur shaft—for distal femoral traction.
  - 4th pulley—to change the angle of traction and prevent equinus deformity at ankle.



Figs 4.2A and B Bohler Braun splint

THOMAS SPLINT (ROBERT JONES) (FIGS 4.3A TO D)

- Designed by **Robert Jones** for immobilization of tuberculosis of knee, but Jones proposed its name as Thomas Splint in honor of his maternal uncle **Hugh Owen Thomas**. This splint is also known as Thomas bed knee splint.
- *Components of splint:*
  - Well padded circular or oval ring.
  - Outer bar with proximal angulation-angulation clears the greater trochanter.
  - Inner bar.
  - W-shaped joint of two bars.
- *Measurement of splint:*
  - *Length of splint (inner bar):* Length between crotch to heel and add 6”–9” to it.
  - For circumference of splint
    - Oblique circumference is taken below gluteal fold and ischial tuberosity.
    - *With normal thigh:* Oblique circumference of thigh and add 2 inches to it.
    - *With affected thigh:* Oblique circumference equal to internal circumference of padded ring.
  - Angle between plane of ring and inner bar-120°
  - Proximal angulation in outer bar at 5 cm from ring.

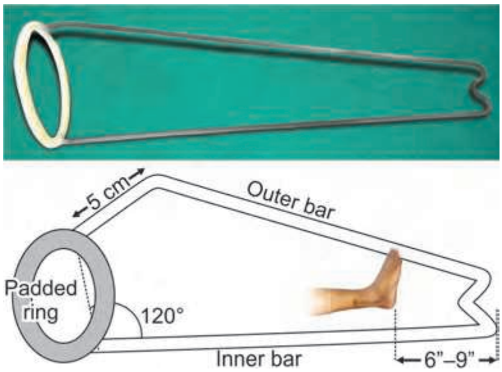


Fig. 4.3A Thomas splint

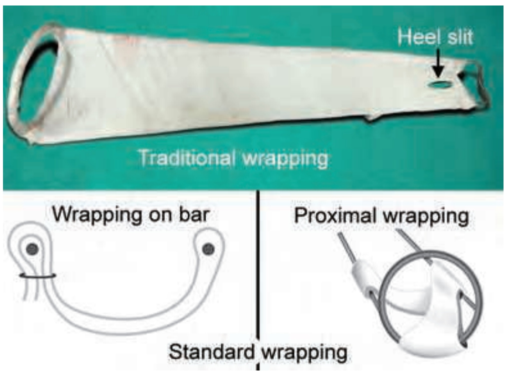


Fig. 4.3B Thomas splint padding

- *Wrapping and padding of splint:*
  - Wrapping of splints in U manner with 6” roller bandage

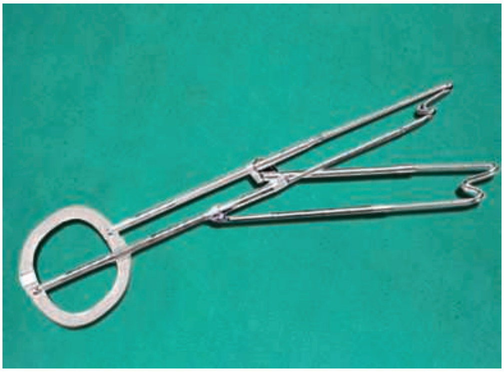


Fig. 4.3C Thomas splint with Pearson component

Fig. 4.3D Bent Thomas Splint

  - *Master pad of* ***Henery****:* A gamgee/cotton pad of size 6″ × 9″ and 2″ thick is placed under the lower part of thigh to maintain the anterolateral angulation of femur.
- *Uses:*
  - For transportation of fractured lower limb.
  - For traction (fixed or sliding) in pediatric fracture shaft femur.

Tobruk Splint

Fixed traction of lower limb on Thomas splint with plaster cast over it. It is used for first aid and transportation.

Fisk Splint

Thomas splint with knee flexion piece which is telescopically adjustable.

Pearson Component (Knee Flexion Attachment)

Knee flexion prevents rotation and also prevents stretching of postcapsule that might causes hyperextension instability.

☑ *Note:* Have you seen bent Thomas splint which act as Bohler's splint without pulley?

BOHLER'S STIRRUP (FIG. 4.4)

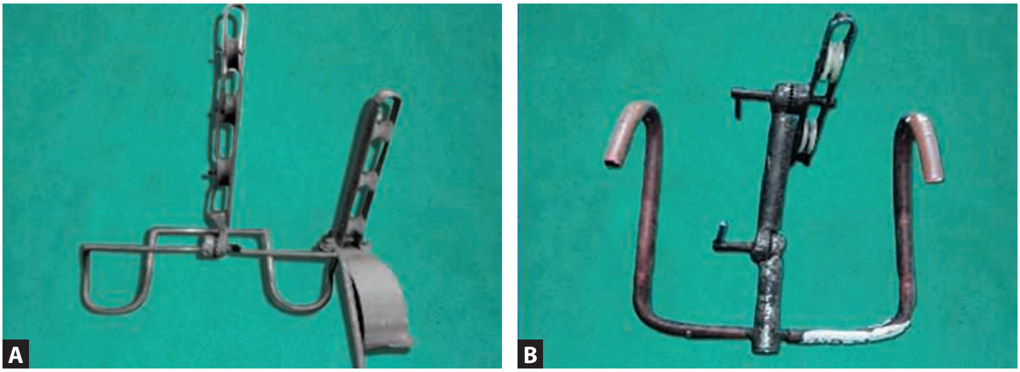
- *Components of Bohler's stirrup:*
  - Loop for traction cord.

Fig. 4.4 Bohler's stirrup

  - Screw securing Steinmann pin.
  - Side limbs.
- *Uses:*
  - As component of skeletal traction.
  - Traction can be applied in any direction. without rotating the pin.

BUCK'S PULLEY (FIGS 4.5A AND B)

- *Components:*
  - Three pulleys as upper, middle and lower.
  - Bed holding frame.
- *Preferred pulley wheels:*
  - *Wheel diameter:* 5–6.25 cm.
  - *Axel-diameter:* 6 mm.
- *Uses:* Different pulleys are used for alignment of distal fragment in relation to proximal fragment by adjusting traction cord on at different heights.



Figs 4.5A and B Buck's pulley

TENSIONIZER/TENSIONER/ K-WIRE STRAINER (FIG. 4.6)

- *Which wire should use:*
  - Ilizarov plain wire.
  - K-wire (2–2.5 mm).
- *Uses:* For pediatric skeletal traction.
- *Why:* Wire can bend without tensioning it.

Fig. 4.6 Tensionizer/tensioner/k-wire strainer

TRACTION (FIG. 4.7)

- A mechanical force applied against a resistance to overcome deforming forces on a fractured fragment or pathologic joint.
- *Benefits of traction:*
  - Relives spasm and pain.
  - Fracture reduction and maintenance.
  - Deformity prevention and correction.
  - Controls movement at fracture site which promotes healing.
- *Traction weight:* On an average, traction weight is equivalent to 10% of body weight but it depends upon following factors:
  - Site of fracture.
  - Skin condition of limb.
  - Bulk and power of muscle.
  - Age and body weight of patient.
  - Friction and mechanical advantage of system.
- *Counter traction (CT):* A force applied apposite to traction force is called counter traction. On the basis of counter traction, traction can be divided into two broad groups:

Fig. 4.7 Traction weight

  - Fixed traction—here leg of the couch need not to be elevated
  - Sliding traction—here leg of couch is elevated with the help of wooden blocks.

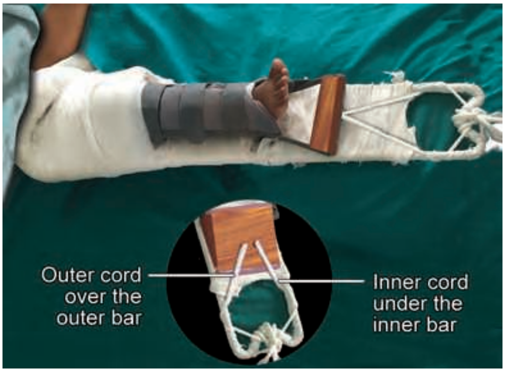


Fig. 4.8 Fixed traction

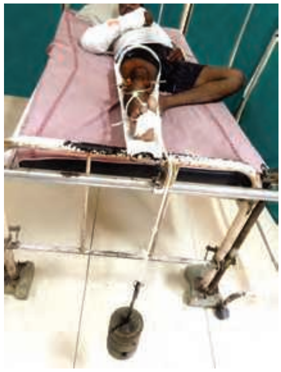


Fig. 4.9 Sliding traction

- *Wooden blocks:*
  - Standard height—9” (6” blocks are also available)
  - 1 inch elevation of couch corresponds to 0.46 kg CT force.

FIXED TRACTION (FIG. 4.8)

- When counter traction obtained by an appliance which takes the purchase on a part of body, arrangement is called fixed traction.
  - Given through skin traction (mainly).
  - *Traction weight:* 2.3 kg.
  - Cord is fixed to splint.
  - Part of the couch is not elevated.
- *Uses:*
  - Maintain undisplaced fractures.
  - Used for transportation.

SLIDING TRACTION (FIG. 4.9)

- When counter traction obtained by weight of all or part of body under influence of gravity, it is called sliding traction.
  - It can be given by both skin and skeletal traction.
  - A traction cord runs over the pulley system.
  - The traction weight is fastened with traction cord.
  - Here counter traction is achieved by elevating the side of couch from where traction weight is passing, e.g.
    - Lower limb traction—foot end of couch is elevated.
    - Cervical traction—head end of couch is elevated.
    - Dunlop traction—arm side of the couch is elevated.
- *Uses:*
  - For fracture reduction.
  - For pathological joint immobilization.

Buck’s Traction

Skin traction kept over pillow, e.g. fracture neck of femur, fracture acetabulum.

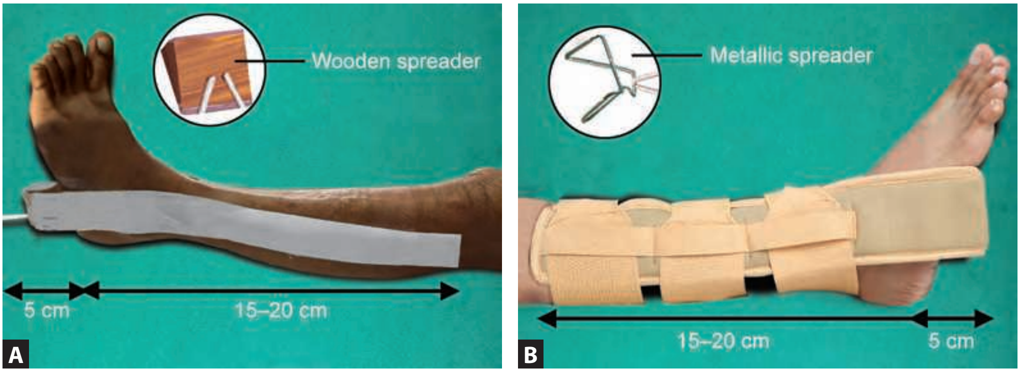
Perkin’s Traction

Skeletal traction kept over pillow, e.g. fracture neck of femur, fracture acetabulum.

☑ *Note:* No splint is used in Buck’s and Perkin’s traction.

SKIN TRACTION (FIGS 4.10A AND B)

- Traction force applied over large area of skin called skin traction.
- Features:
  - Apply distal to fracture site; do not extend it too proximal to fracture site otherwise traction will be inefficient.
  - Two types of skin traction are commonly used:



Figs 4.10A and B Skin traction. (A) Adhesive type; (B) Nonadhesive type

- Adhesive (maximum weight—6.7 kg)
  - Allergic—zinc oxide as adhesive material.
  - Nonallergic—acrylic adhesive material.
- Nonadhesive (maximum weight—4.5 kg) and used for:
  - Allergic skin.
  - Thin and atropic skin.

- Skin traction kit contain:
  - *Skin strap:* Recommended length of strap is approx 15–20 cm and add 5 cm to it that loops beyond the distal most part of the limb; loop ensures free movement of toes or fingers.
  - Crepe bandage.
  - Spreader (wooden or metallic)—7.5 cm.
  - Cotton roll.
  - Tincture benzoin.
- How to apply skin traction:
  - Do shaving of skin hairs.
  - Apply tincture benzoin in nonadhesive type.
  - Do padding over bony prominences if any.
  - Apply strapping by the side of limb.
  - Apply crepe bandage around the limb.
- *Position of strap in lower limb skin traction:*
  - Axis—tip of greater trochanter to lateral malleoli.
  - Medial position of strap—anterior to the this axis.
  - Lateral position of strap—lower to this axis.

  Why so?—to promote medial rotation.
- *Complications:*
  - Skin allergy due to adhesive material.
  - Pressure sore due to inadequate padding over bony prominences.
  - *Common peroneal nerve palsy:*
    - Due to lateral rotation of limb.
    - Direct compression by splint.
    - Sliding skin traction compressing over fibular head.
- *Contraindications:*
  - Injured skin (abrasion, severe bruise or laceration).
  - Skin disease like dermatitis.
  - Gangrene or varicose ulcer following impaired circulation.
  - Overriding of fracture fragment where skeletal traction is needed.

☑ *Note: Pediatric fracture shaft of femur and skin traction: (Few recommendations)*
- There is tendency of slippage of straps of skin traction due to continuous and prolonged traction acting over limb and the traction force will be ineffective when straps would slip more distal to fracture site. Hence, the free ends of straps of skin traction exceed 1–2 inches proximally to the fracture site so that even after slight slippage of straps, the resultant traction force will minimally affected.

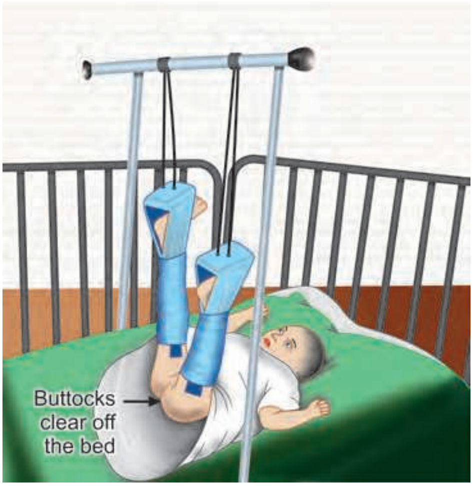


Fig. 4.11 Bryant's/Gallow's traction

Fig. 4.12 Dunlop's traction

BRYANT'S/GALLOW'S TRACTION (FIG. 4.11)

- *How to apply:*
  - Apply adhesive skin traction on both lower limbs.
  - Tie traction cord to overlying frame (Balkan frame).
  - Raise buttock to just clear the mattress.
  - If knee flexion needed—posterior gutter splint should be used.
- *Check for circulation status:* Most important in firs 24 hours and look for color, temperature, passive stretch pain, pulse, capillary re-filling, edema and sensation of foot.
- *Age and its relation to blood supply in distal part of leg in Gallow's traction when knee is hyperextended:*
  - *Age <2 years:* Insignificant.
  - *Age 2–4 years:* Precarious circulations (if needed use posterior gutter splint).
  - *Age >4 years:* Definite compromise, so absolutely contraindicated.
- Indication and best candidate
  - Given for fracture shaft femur.
  - *Age:* Less than 2 years or weight less than 16–18 kg.
- *Modified Bryant's:*
  - *Indication:* For child having dysplasia of the hip developmental (DDH) of less than 1 year age.
  - *Modifications are as:*
    - *Initial 5 days:* Vertical position of limb.
    - *Alternate days:* 10° abduction of each limb.
    - *In 3 weeks:* Full abduction.

DUNLOP'S TRACTION (FIG. 4.12)

- *Position:*
  - *Shoulder:* 45° abduction.
  - *Elbow:* 45° flexion.
- *How to apply:*
  - Padded sling over distal humerus.
  - Weight $\propto$ size of child; start with 0.5–1 kg— followed by gradual increase under image intensifier up till reduction.
  - Elevate same side of bed for counter-traction.
  - Look for circulation hourly.
- *Indication:*
  - For supracondylar fracture and inter-condylar fracture humerus.

SKELETON TRACTION

- Traction forces acting directly through a part of a bone is called sketetal traction.
- *Features:*
  - It is also applied distal to the fracture site.
  - Applied through a pin or K-wire.

- More traction weight can be given.
- *Equipment for skeletal traction:*
  - Steinmann pin.
  - T-handle with Jacob's chuck.
  - Surgical blade.
  - Xylocaine injection.
  - Syringe with needle.
  - Surgical gloves.
- *Steps of traction application:*
  - Stab incision.
  - Secure underlying structures.
  - Keep the limb in position of 15° external rotation (lower limb).
  - Penetrate horizontally.
  - Apply tincture benzoin soaked 2 separate gauze over pinskin interface.
- *Direction of entry of pin:* Always keep the entry point of pin towards the where there are neurovascular bundle because there is control over pin at entry point but not at exit point.
- *Complications:*
  - Pin track infection (ring sequestrum).
  - Physeal injury in children.
  - Ligamentous injury if heavy traction for prolonged periods.
  - Distraction of fracture site.
  - Neurovascular injury.
  - Splintering of cortex (due to hammering).
  - Incorrect placement of pin leading to:
    - Altered direction of traction.
    - Rotation of limb.
    - Make splint application difficult.
- *Care of pin tract:*
  - Daily dressing is preferred.
  - Two step dressing:
    - First wipe the pin-skin interface with Spirit (Some prefer normal saline).
    - Then apply cotton gauze soaked with betadine or chlorhexidine solution.
  - Do not apply pressure bandage around the limb adjacent to Steinmann pin due to risk of local edema or pressure sore.
  - Do local examination for any pin-tract infection. Tenderness, warmth, pus, loosening of pin, etc. if so remove skeletal traction and apply some other modality of traction.
  - Prophylactic antibiotic is also preferred in systemically ill patient.

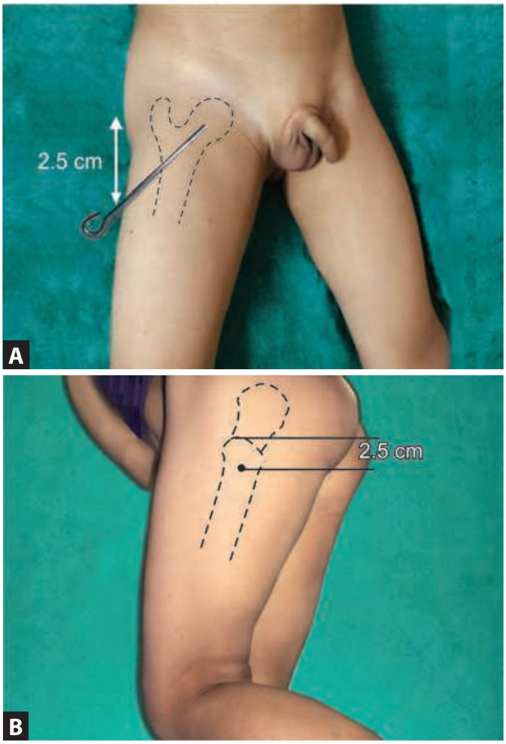
LATERAL UPPER FEMORAL TRACTION (FIGS 4.13A TO C)

- *Equipment:* Screw eye.
- *Entry point:* 2.5 cm below the most prominent part of GT, midway between anterior and posterior border of shaft of femur.
- *Technique:*
  - Neutralize anteversion of hip by internal rotation of hip.
  - Directed towards opposite ASIS (anterior superior iliac spine).
  - Advance screw up to 3.75–5 cm in neck of femur.
- *Traction weight:* 4.5–9 kg and counter traction by elevation of cranial and caudal leg of affected side.
- Lateral upper femoral traction is commonly combined with upper tibial traction. Here counter traction is obtained by differential elevation of leg of couch, e.g. if traction is applied over right sided proximal femur the blocks in the leg will be applied as follows:
  - Cephalic end right arm side—low block
  - Cephalic end left arm side—no block
  - Caudal end right leg side—high block
  - Caudal end left leg side—low block
- *Duration of traction:* 4–6 weeks.
- *Indications:*
  - Central fracture dislocation of hip.
  - Acetabular fracture.

☑ *Note:* Lateral upper femoral traction is commonly combined with upper tibial traction.

DISTAL FEMORAL TRACTION (FIG. 4.14)

- *Entry point of pin:*
  - Direction—medial to lateral.
  - Positioning of entry point.
    - One line along anterior border of head of fibula.
    - Another line along upper border of patella (before backward).



Figs 4.13A and B Site for lateral upper femoral traction application

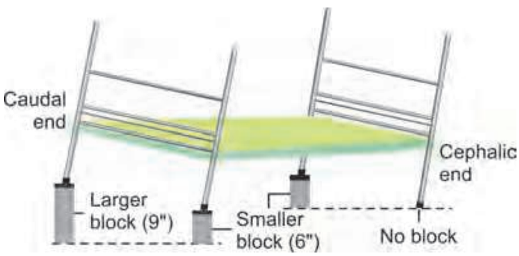


Fig. 4.13C Site for differential elevation of leg of couch application

- Enter from corresponding junctional point of two above lines on medial side.

- *Complications:*
  - Quadriceps fibrosis.
  - Knee stiffness.
- *Indication:* For fracture shaft of femur, acetabular fracture dislocation.

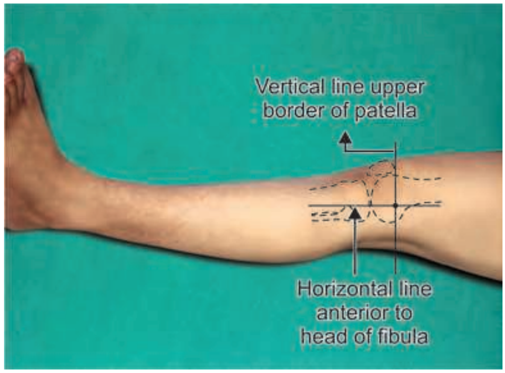


Fig. 4.14 Site for distal femoral traction application

☑ *Note:* Change the distal femoral traction to upper tibial traction after 3 week due to risk of pin loosening.

UPPER TIBIAL TRACTION (FIGS 4.15A TO C)

- *Ways of traction application:*
  - *On Thomas splint with Buck's pulley:* Fracture shaft femur in child-ren.
  - *On Bohler-Braun splint:* Intertrochanteric fracture, fracture shaft of femur, fracture supracondylar femur.
  - *On pillow (perkins):* Fracture neck femur.
- *Entry point of pin:*
  - *Direction:* Lateral to medial.
  - 2 cm below and behind the tibial tubercle.
- *Danger:* Common peroneal nerve palsy.

☑ *Note:* Role of flexed knee in reduction of fracture shaft femur when traction is applied via upper tibial traction:
  - In flexed knee attitude, the periarticular ligaments of knee are relaxed and traction forces directly act over two antagonistic group of muscles (quadriceps and hamstrings) hence deforming forces are balanced and reduction is achieved.
  - In extended knee attitude (locked knee position) the traction forces are spent in stretching the periarticular ligaments not for fracture reduction. Side by side

Fig. 4.15A Site for upper tibial traction application

in the extended knee position the distal fragment of femur and the tibia acts as a single unit which does not prevent rotation at fracture site.

DISTAL TIBIAL TRACTION (FIG. 4.16)

- *Entry point of pin:*
  - *Direction:* Medial to lateral.
  - Positioning of entry point:
    - One point—5 cm above ankle joint.
    - Other point—midway between anterior and posterior border of tibia.

Fig. 4.15B Upper tibial traction on Bohler-Braun splint

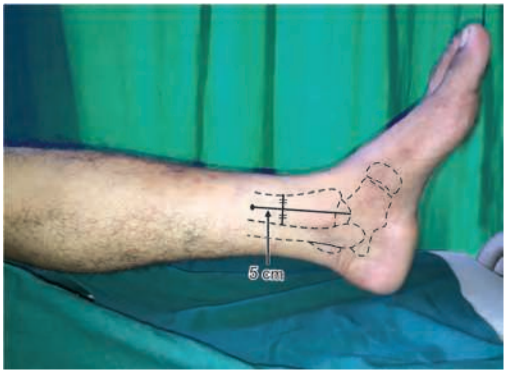


Fig. 4.16 Site for distal tibial traction application

Fig. 4.15C Upper tibial traction on pillow

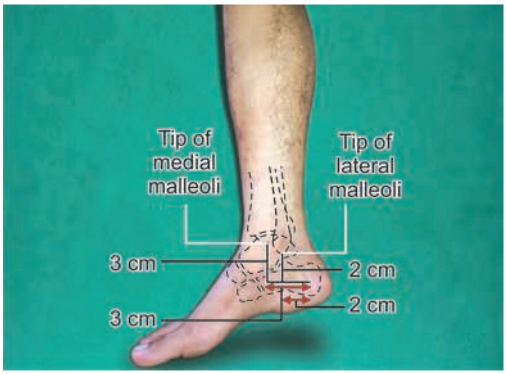


Fig. 4.17 Site for calcaneal traction application

- *Indication:* Proximal tibial fractures and knee fracture dislocation.

CALCANEAL TRACTION (FIG. 4.17)

- *Entry point of pin:*
  - Direction—medial to lateral.
  - *Positioning of entry point:*
    - *Medial side:* 3 cm below and behind the medial malleolus.
    - *Lateral side:* 2 cm below and behind the lateral malleolus.
- *Indications:*
  - Distal tibial fractures.
  - Ankle fracture dislocation.

OLECRANON TRACTION (FIG. 4.18)

- *Entry point of pin:*
  - *Direction:* Medial to lateral.
  - *Positioning of entry point:*
    - 3 cm distal to tip of olecranon process.
    - Just deep of subcutaneous border of ulna.
- *Risk:* Injury to ulnar nerve.
- *Indication:* Supracondylar and intercondylar fracture of distal humerus.

☑ *Note:* A screw eye can also be used for olecranon traction.

Fig. 4.18 Site for olecranon traction application

METACARPAL TRACTION (FIG. 4.19)

- *Entry point of pin:*
  - *Direction:* Lateral to medial.
  - *Positioning of entry point:*
    - From 2nd to 3rd metacarpal.
    - Transversely perpendicular to long axis of radius.
    - 2–2.5 cm proximal to distal end 2nd metacarpal.
- *Indication:* Distal radius fracture and wrist injuries.

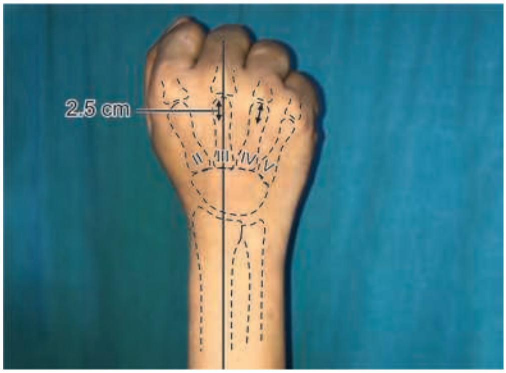


Fig. 4.19 Site for metacarpal traction application

AXIAL TRACTION (CERVICAL AND PELVIC)

HEAD HALTER TRACTION (FIGS 4.20A AND B)

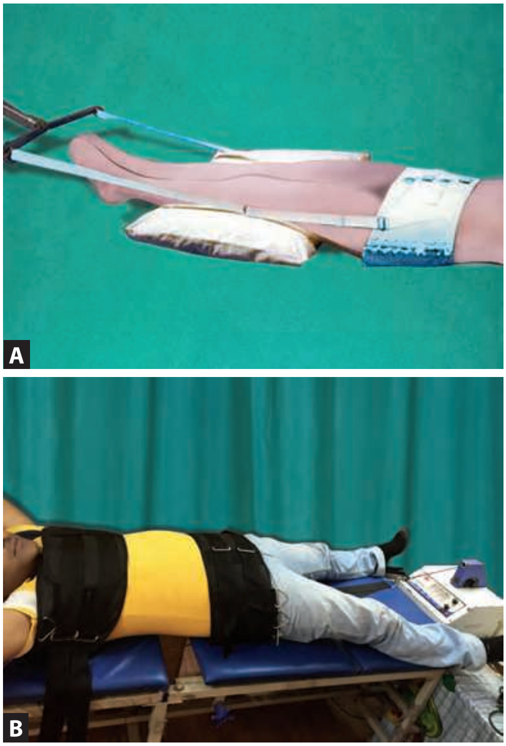
- *Two types:*
  - Canvas head halter—with chin and occiput rest.
  - Crili head halter—with forehead and occiput rest.

Figs 4.20A and B Head halter traction

- *Parts of Canvas head halter:* Most common variety.
  - Chin and occiput rest.
  - Metal spreader with hook.
  - Side piece.
- *Total effective traction weight:* 10–15% of body weight.
- *Use:*
  - Cervical spondylosis.
  - Cervical trauma.
- *Complications:*
  - Pressure sore.
  - Difficulty in eating.

PELVIC TRACTION (FIGS 4.21A AND B)

- *Components:*
  - Canvas harness.
  - Side straps.
  - Metal spreader with hook.

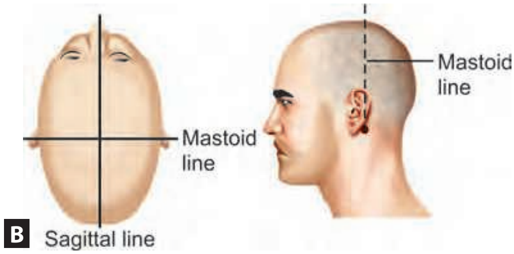


Figs 4.21A and B Pelvic traction

- *Total effective traction weight:* 20–30% of body weight (most effective range).
- *Uses:* In prolapsed intervertebral disc.

CERVICAL SKELETAL TRACTION (FIGS 4.22A AND B)

- *Ways of traction application:*
  - By Crutchfield tong.
  - By barton tong.
  - By garden well.
  - By cervical halo.
- *Traction weight:* Max (9.1–18.2 kg) and for counter traction head end of couch is elevated.
- *Indications:*
  - For reduction of fracture dislocation of cervical spine.
  - Maintenance of reduction.
  - After operative fusion.



Figs 4.22A and B (A) Cervical traction; (B) Site for Crutchfield tong application

- Cervical spondylosis with severe nerve compression.

- *Crutchfield tong application:*
  - *Instrumentation:*
    - Crutchfield tong.
    - Guarded drill bit.
  - *How much penetration in scalp bone:*
    - 3 mm (children)
    - 4 mm (adult)
  - *Which bone:* Parietal bone (outer-table).
  - *Point of entry:* Three finger breath above pinna and in line of mastoid (sagittal line and intermastoid line).
  - *Tightening of tong:* Every day for first 3–4 days and then as required.
  - *Direction of traction:* As per position of fracture/dislocation shown by image-intensifier or radiographs.
  - *Traction weight:* For head 2.5 kg add ½ kg for each cervical vertebrae.

Cervical level and weight (pound) correlation		
Cervical level	*Minimum weight (pound)*	*Maximum weight (pound)*
C_1	5	10
C_2	6	12
C_3	8	16
C_4	10	20
C_5	12	24
C_6	15	30
C_7	18	35

  - Maintenance weight—2.3–3.2 kg. (5–7 pound) for 6–10 weeks to prevent traction over cervical vessel.
  - *Heavy traction method of reduction:*
    - Start with 2.5–5 kg weight.
    - Increase 5 kg at 15 minutes interval till reduction is achieved (maximum: 30 kg).
    - Maintenance with— 5–7.5 kg weight.
  - *Contraindication of cervical skeletal traction:*
    - C2 (Hangmann fracture) type IIA.
    - Cervical flexion-distraction (facetal dislocation)—leading to disc herniation.
- *Garden-well tonge:* These are U-shaped tongs for cervical traction having pressure controlled pins that are inserted into skulls at opposite ends.

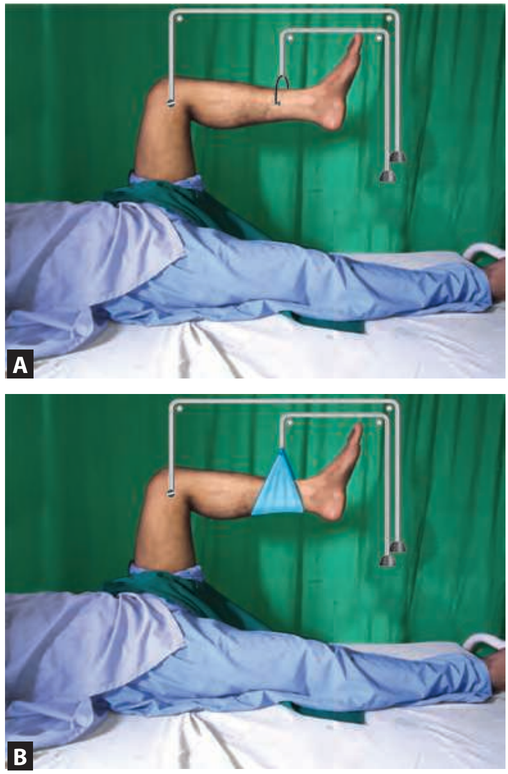
SPECIAL TYPE OF TRACTION IN LOWER LIMB

BOOT AND BAR (FIG. 4.23)

- *Components:*
  - Well padded boot cast.
  - Wooden scale as derotation bar (6" length).
  - POP bandage loop for traction.
- *Indication:* For conservative treatment of intertrochanteric fracture or impacted

Fig. 4.23 Boot and bar

Fig. 4.24 Charnley's traction unit



Figs 4.25A and B Ninety-ninety traction

fracture neck of femur specially in medically moribund patients.

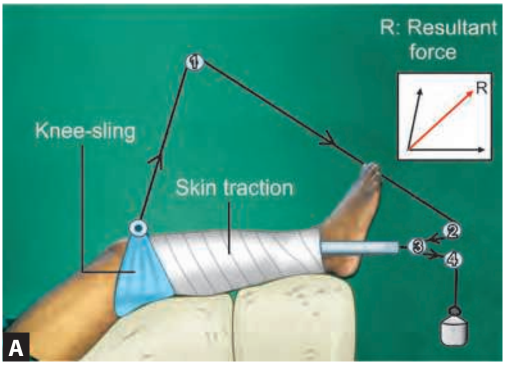
- *Follow-up:*
  - *Patient positioning:* Maintain 45° abduction of limb by keeping pillow between the two thighs.
  - Traction weight maintenance.
  - Serial fracture site examination.
- *Complications:*
  - Pressure sore/bed sore.
  - Deep vein thrombosis.
  - Respiratory and cardiac complications.
  - Malunion.

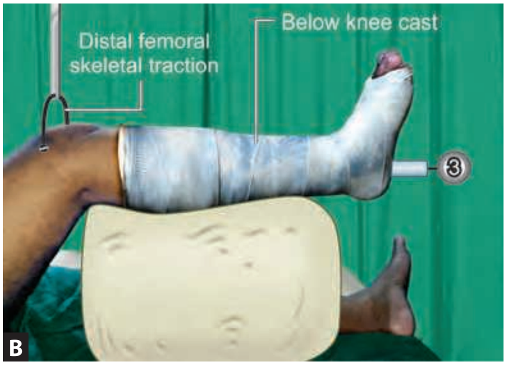
CHARNLEY'S TRACTION UNIT (FIG. 4.24)

- *Components:*
  - Upper tibial traction pin with Bohler's stirrup.
  - Below knee plaster cast.
  - Derotation bar (6 inch length) and midway between heel and toes.
- *Indication:* Fracture shaft femur.
- *Advantages:*
  - No common peroneal nerve palsy (due to below knee cast).
  - Prevents equines deformity at ankle.
  - Tendoachilles is protected from sore by padded cast.
  - Prevents rotation of distal fracture fragment.
  - Ipsilateral tibial fracture can be managed simultaneously.

NINETY-NINETY TRACTION (OBLETZ 1946) (FIGS 4.25A AND B)

- Combination of two tractions that maintain the both hip and knee in 90° of flexion.





Figs 4.26A and B (A) Russell traction; (B) Modification in Russell traction

- *Traction-1:* It is the main traction unit which acts on the pathology. It is given as distal femoral or upper tibial skeletal traction.
- *Traction-2:* It is supportive traction unit which holds the leg in air. This can be given either lower tibial skeletal traction or below knee plaster cast.
- *Indications:*
  - *Proximal 1/3rd femur fracture (why?):* Here proximal fragment is flexed and abducted. It is impossible to maintain the alignment of distal fragment to proximal fragment for a patient moving on bed.
  - Posteriorly compound fracture shaft of femur due to difficult wound care.

Fig. 4.27 Agnes-Hunt traction [for fixed flexion deformity (FFD) of hip]

RUSSELL TRACTION (HAMILTON RUSSELL, 1924) (FIGS 4.26A AND B)

- *Component of traction:*
  - Skin traction in leg.
  - Knee sling.
  - System of pulley:
    - *Pulley-1:* Just anterior to knee.
    - *Pulley-2 and 4:* At the level of foot.
    - *Pulley-3:* Attached with spreader of skin traction.
- *Effective traction:* It is the resultant force which act in the direction of long-axis of femur.
- *Indications:*
  - Fracture shaft of femur especially in pediatric cases.
  - Triple deformity of knee (tuberculous and rheumatoid) as in flexion deformity or posterior subluxation.
- *Modification in Russell traction:*
  - Distal femoral skeletal traction in place of knee sling.
  - Below knee cast is applied in place of skin traction and 3rd pulley is fixed with cast of sole region.

AGNES-HUNT TRACTION [FOR FIXED FLEXION DEFORMITY (FFD) OF HIP] (FIG. 4.27)

- *Components of traction:*
  - Single hip spica (unaffected limb).
  - Leg sling

- Skin traction over Thomas splint (affected limb).
- *Why spica in 90° position:*
  - It obliterate the lordosis and reveals fixed-flexion deformity of hip.
  - Spica covering the lumbar region act as a counter point for deformity correcting forces.
- *How to apply traction:*
  - Flex the both hip up to 90° to obliterate lordosis.
  - Apply single hip spica in unaffected limb in above position.
  - Apply a leg sling to hold leg in spica.
  - Apply a skin traction in unaffected limb and kept over Thomas splint.
  - Decrease the height of Thomas splint as the deformity corrected.
- *Indication:* Fixed flexion deformity of hip.

CHECKLIST FOR EFFECTIVE AND SAFE TRACTION

- *Appropriate splint:* Care for dimension of splint.
- *Padding of splint:* With cotton and roller bandage.
- *Strappings of skin traction:* Wrinkle free and creaseless.
- *Spreader:* Wooden or metallic as a part of skin traction kit.
- *Bandages:* Elastic bandages for wrapping around limb in skin traction.
- *Limb position:* As per demand of fracture pattern or pathology.
- *Direction of traction cord:* By adjusting the height of pulley. Traction cord should not touch any part of bed or ground.
- *Traction weight:* According to type of traction (skin or skeleton) and age of patient.
- *Counter traction:* By elevating the couch legs as per requirement.
- *Padding of limb:* To steadies the limb over splint and reduce angulation at fracture site.
- *Bony prominences:* Proper padding is mandatory.

CARE OF PATIENT ON TRACTION

- *Check for skin complication like pressure sore:* Proper padding over pressure point, e.g. malleoli, Achilles tendon, heel, etc. (Keep water filled gloves or slit padding of splint near heel and tendoachilles.
- *Check for pin tract infection, if there is any pus or systemic feature:* Do regular dressing and investigate for infection.
- Check for distal vascular status as shown by feeble pulse, pale, cool, swollen finger or digits— release pressure point if any.
- *Check for any neurological complication, e.g. common peroneal nerve palsy:* Release pressure point.
- Continued physiotherapy.
- Check for improvement in ailment for which traction is applied.

CHAPTER

5

Patients on External Fixators

External fixators are proven modality of treatment in orthopedics. Although they lie for a prolonged period in the connection of patient body; hence their care is essential to prevent complication. The outline of various types of fixators are given here.

External fixator—classification:

1. Pin fixator
2. Ring fixator.

Broad categories of fixators
AO type external fixator
Limb reconstruction system (LRS)
Ilizarov fixator
Taylor spatial frame (HEXAPOD)
Joshi external stabilization system (JESS)

PIN FIXATOR AO TYPE FIXATOR (FIG. 5.1A)

- *Components:*
  - *Schanz screw: Parts:*
    - Tip—make a drill hole before inserting it.
    - Thread—threaded portion engages in far cortex of bone.
    - Shaft—shaft engages in near cortex of bone.
    - Top—quadrangular top firmly holded by T-handle.

      Diameter of Schanz pin 2–6 mm at interval of 0.5 mm
    - *Femur, tibia and humerus:* 4.5 mm, 5.0 mm, 5.5 mm
    - *Radius and ulna:* 3.5 mm
    - *Metacarpal and metatarsals:* 2.5 mm.
  - Clamp.
  - *Central body/connecting rod:* (AO type—11 mm diameter, 10 cm to 60 cm length)
  - Coupling.
- *Classification of external frame:*

Type	*Frame*
I	Unilateral (UL)
IA	UL uniplanar
IB	UL biplanar
II	Bilateral (BL)
IIA	BL uniplanar
IIB	BL biplanar
III	Modular (various planes).

Fig. 5.1A Pin fixator

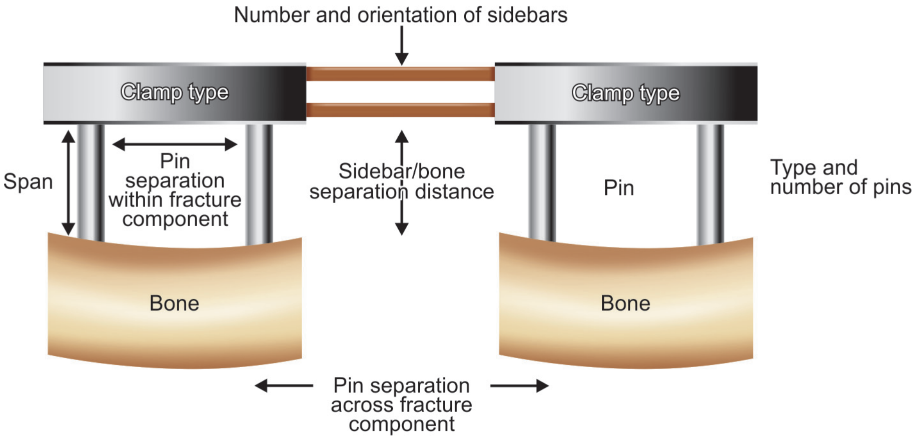


Fig. 5.1B Factors affecting stiffness of fixator

- *Factors affecting stiffness of fixator (Fig. 5.1B):*
  - Number of pins and their diameter ∝ stiffness.
  - Distance between pins ∝ stiffness.
  - Number of parallel rods and their diameter ∝ stiffness.
  - Distance between the bone and rod ∝ 1/ stiffness (optimal gap –4 cm for ease of dressing).
  - Pin placement nearer to fracture site increases the stability.
- *Preloading:* A technique to promote strength between pin and bone interface to overcome muscular forces acting over fracture fragment. Two methods are used for preloading
  - *Radial preloading:* Radial preloading is done by designed misfit.
    - When a larger diameter pin is inserted into smaller diameter predrilled hole. This is called designed misfit.
    - Optimal misfit is 0.1 mm
    - Misfit >0.3 mm leading to mechanical damage, instability, micromotion induced resorption of bone.
  - *Axial preloading:* A axial preloading is achieved by distracting the pins along the long axis of bone
    - Pin distraction is in opposite direction across the fracture site.
    - It produces gape at one of the pin-bone interface. (Risk of future loosening)
    - It is less commony practised.
- Dynamization
  - What dynamization does?
    - Loading at fracture site.
    - Micromotion at fracture site.
  - How to do dynamization ?
    - Use of elastic frame with overall low rigidity.
    - Progressive dismantling of frame.
    - Weight bearing.
    - Increase connecting rod and skin distance.
    - Loosening of clamp and connecting rod interface diagonally to fracture site.
- Safest area for Schanz screw (half pins) application in various bones:

Bone	*Safest zone*
Scapula	Coracoid process
Humerus:	
• Upper third	Lateral aspect
• Middle third	Anterior aspect
• Lower third	Lateral aspect
Radius:	
• Middle third	Posterior aspect
• Distal third	Lateral aspect
Ulna	Along posterior border
Metacarpal	2nd metacarpal dorsal aspect
Pelvic bone	• Iliac tubercle • Just posterior to anterior superior iliac spine • Just proximal to anterior inferior iliac spine
Femur:	
• Entire length	Lateral aspect
• Middle third	Anterior aspect
Tibia	
• Entire length	Perpendicular to shin (medial surface)
Fibula	Rarely used
Metatarsal	1st metatarsal dorsal aspect. Sometime 2nd also

- *Removal of external fixator and intramedullary nailing:* The timing for intramedullary nailing after removal of external fixator is controversial but it chiefly depends upon the time period for which external fixator persisted in affected limb. This time corresponds to the period of wound healing.
  - If ex-fix persisted for less than 3 week—minimal chance of pin tract infection. Do immediate IM nailing after removal of external fixator.
  - If ex-fix persisted for more than 3 week—maximum chances of pin tract infection hence wait for 4 weeks after removal of external fixator. Maintain the limb in slab and continue antibiotic according to culture sensitivity of pin tract.

LIMB RECONSTRUCTION SYSTEM (FIG. 5.2)

Peculiarities of Schanz screw of LRS:

- Tapering design threads of Schanz screw.
- Predesigned misfit among threads; increases the hold of screw into the bone with each turn of tightening.
- No protrusion of screw (2 mm acceptable) beyond distal cortex; because reversal of screw will produce loosening due to its tapering design—use C-arm, e.g. for 5.5 mm tapering design Schanz screw thread diameter varies as: near tip—3.5 mm, in the middle—4.5 mm, near shaft— 5.5 mm.

ILIZAROV SYSTEM (FIG. 5.3)

- *Principle of distraction osteogenesis:* Gradual distraction at low energy osteotomy site can produce any amount of new bone from parent bone.
- *Various components of Ilizarov frame are:*
  - *Rings:* Semicircular half ring
    - Made up of stainless steel and Epoxy resin reinforced with carbon fibers.
    - *Internal diameter range:* 80–240 mm (12 types)
      - For children (80 mm, 100 mm, 110 mm, 120 mm, 130 mm, 140 mm)
      - For adult (150 mm, 160 mm, 180 mm, 200 mm, 220 mm, 240 mm)

Fig. 5.2 Limb reconstruction system (LRS) (*Courtesy:* Dr Shailendra Khare)

   - *Number of holes per ring:* 18–28
   - *Hole diameter:* 8 mm; each hole 4 mm apart
 - *Arches (Italian plates):* 90° and 120°
 - *Bolts and nuts:*
   - *Bolts:* Head diameter 10 mm, Shaft diameter 6 mm, pitch 1 mm
   - *Nuts:* Diameter 6 mm, height 6 mm, 5 mm and 4 mm
 - *Connecting rods:* Diameter 6 mm, length—6–40 cm
 - *Wires:*
   - Plain and olive
   - For children 1.5 mm diameter wire and for adult 1.8 mm diameter wire.
   - Bayonet tip for cortical bone and trocar tip for cancellous bone.
 - *Wire fixation bolts:*
   - Cannulated with 2 mm hole
   - Slotted
 - *Washers:* Internal diameter—7 mm, thickness—1.5–4 mm
 - *Other component:*
   - Rancho
   - Post (male and female)
   - Twisted plates
   - Connecting plates (straight or curved)
   - Hinge (male and female)
   - Distractors, etc.
- *Tensioning limits of Ilizarov wire:* The maximum limit of tension are 90 kg for 1.5 mm wire and 130 kg for 1.8 mm wire. What happens when more tension is given?
  - Risk of slippage of wire at wire holding bolt.
  - Wire will be broken.
- *Principle of osteotomy:*
  - Stable fixation.
  - Low energy osteotomy (no injury of periosteum and endosteum).
  - Metaphyseal location of osteotomy.
  - Latency period of distraction is 5–7 days.
  - Distraction rate 1 mm/day.
  - Rhythm of distraction 2–4 times a day.
- Trampoline effect and Accordion maneuver
  - *Trampoline effect*: When a limb worn with Ilizarov frame is axially loaded or unloaded (e.g. weight-bearing or similar action) it induces osteogenesis.
  - *Accordion maneuver:* The alternate cycle of distraction and compression to accelerate bone regeneration.

☑ *Note:* The optimum RPM of drill machine used for insertion of Ilizarov wire is 45.

Hybrid System (Catagni et al.) (Fig. 5.4)

- This system uses combination of Ilizarov wires and half pins.
- *Two types:*
  1. Traditional hybrid system-partial replacement of Ilizarov wire with half pins, e.g. tibia
  2. Advanced hybrid system-total replacement of Ilizarov wire with half pins, e.g. femur
- *Hybrid fixator in periarticular tibial fracture:*
  - This is a combination of AO external fixator and Ilizarov ring fixator.

Fig. 5.3 Ilizarov system
(*Courtesy:* Dr Shailendra Gupta)

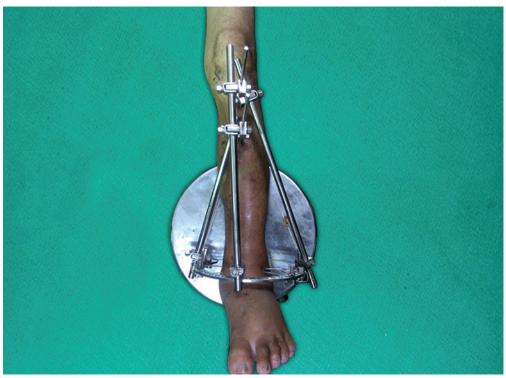
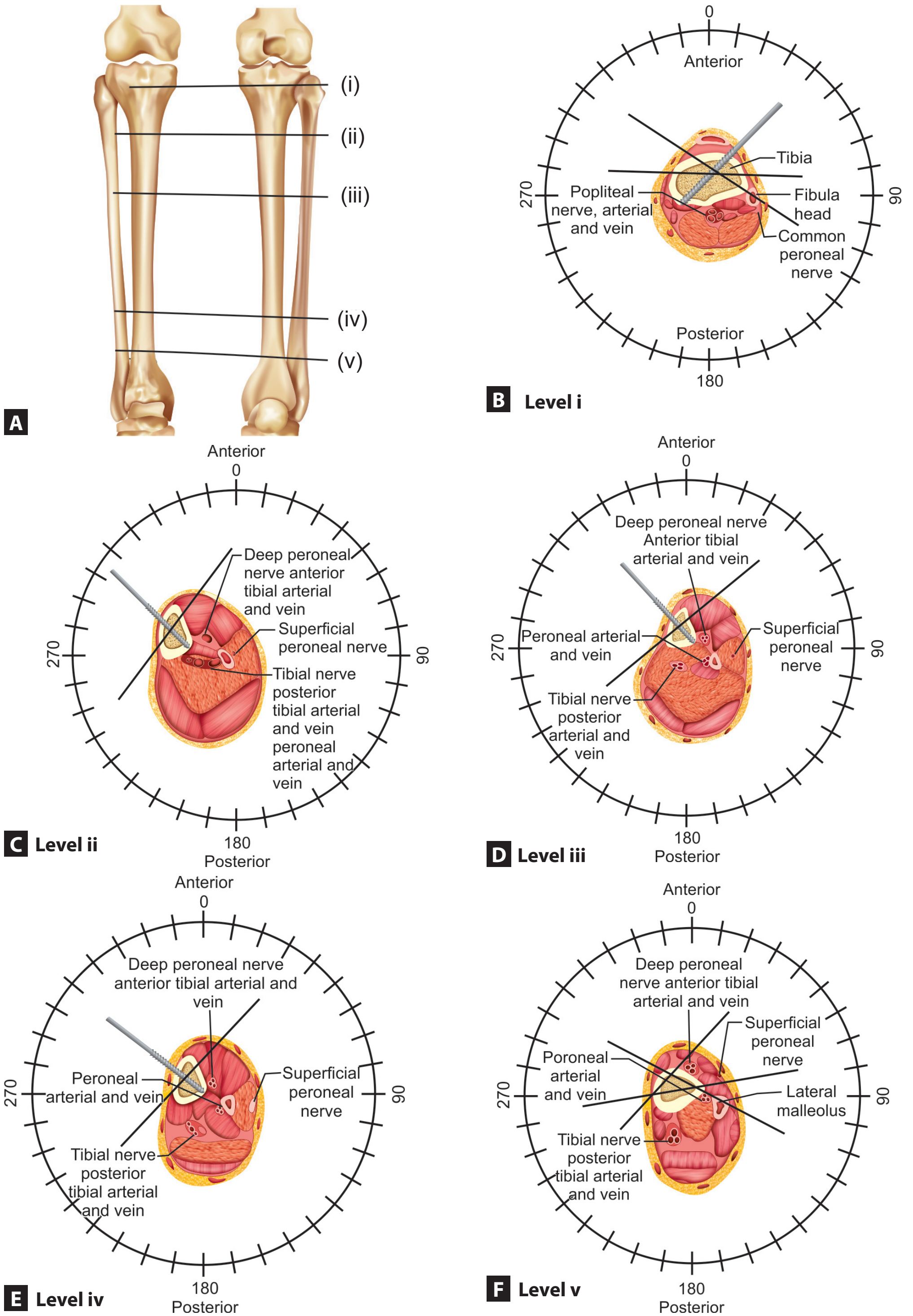


Fig. 5.4 Hybrid fixator



Figs 5.5A to F (A) Anterior and posterior view of tibia and fibula: (B to F) Ilizarov wire application at level (i), (ii), (iii), (iv), (v) from top to bottom

- Equally useful in periarticular fracture in proximal and distal tibia.
- *Advantages:*
  - Less cumbersome than Illizarov.
  - More stability than AO external fixator.
  - Less number of illizarov wire hence minimal wire related complication.

- *Both bone leg (tibia fibula) and application of Ilizarov wire (Figs 5.5A to F):*
  - Upper metaphyseal
  - Upper third
  - Middle third
  - Lower third
  - Lower metaphyseal

TAYLOR SPATIAL FRAME (FIG. 5.6)

- This is an HEXAPOD device invented by orthopedic surgeon Charles Taylor.
- Its acts on the principle of distraction histogenesis same as Ilizarov system
- Two or more aluminium or carbon frame rings connected by six struts.
- Each strut can be independently lengthened or shorten to achieve desired results as compression or lengthening.
- Frame is connected to bone by wires and can be manipulated in six axes (ant-post/mediolateral/shortening-lengthening).
- Angular, translational, rotational, and length deformities can all be corrected simultaneously.

JOSHI EXTERNAL STABILIZATION SYSTEM (FIG. 5.7)

- This system was developed an Indian orthopedic surgeon **Dr Braj Bhusan Joshi**.
- *Principle of differential distraction Histogenesis:* Different rate of distraction at two curvatures of body parts with help of special metallic assembly.
- *Basic components of JESS:*
  - *Connecting rods:* Straight, L- and Z-shaped
  - Distractors
  - *Link joint:* α, β clamps
  - *K-wires:* 1.2 mm, 1.5 mm, 2 mm diameter of 15–20 mm length

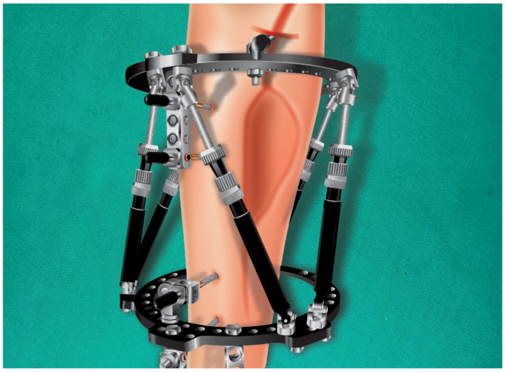


Fig. 5.6 Taylor spatial frame (TSF)

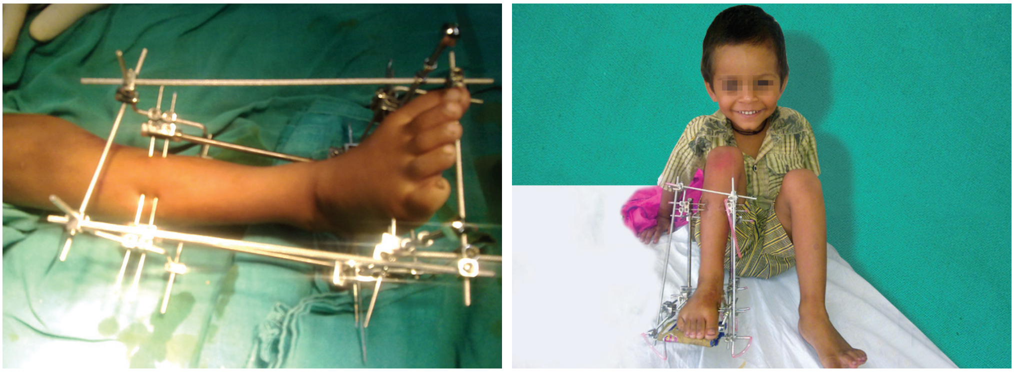


Fig. 5.7 Joshi exrenal stabilization system (JESS)

CHAPTER

6

Miscellaneous Equipment

On an above there are many things in the ward which are kept around the patient. Their knowledge for all medical personnel working in ward is essential for proper functioning. Out of those few important equipment are being mentioned here.

ORTHOPEDIC BED WITH BALKAN FRAME OR BIM (FIG. 6.1)

- This frame was first used during **Balkan war** (1st World War)
- *Components:*
  - Vertical uprights
  - Horizontal bars.
  - Monkey trapeze.
  - Pulleys.
- *Use:*
  - Trapeze used for personal hygiene and physiotherapy.
  - Bars and Pulleys are used for applying various types of tractions such as upper lateral femoral traction, Gallow's traction, etc.

Fig. 6.1 Orthopedic bed with Balkan frame or bim

AIR MATTRESS (FIG. 6.2)

- *Principle:* Alternate inflation and deflation of pressure chambers fitted in the bed.
- *Two types:*
  1. Fixed setting.
  2. Variable setting.
- *Advantages:*
  - Light weight.

Fig. 6.2 Air mattress

- Compact.
- Easy for travel.
- Easy fitting on bed.

- *Uses:*
  - For prolonged recumbency.
  - For pressure sore patients.
  - Spinal cord injury patients.

☑ *Note:* A patient is said to be prolonged bedridden if he is restricted to bed for more than 48 hours.

COMPRESSION STOCKINGS (FIG. 6.3)

Fig. 6.3 Compression stockings

- Specialized hosiery to prevent occurrence or progression of venous disorder
- *Principle:*
  - Compression of limb reduces diameter of peripheral veins
  - This increases venous flow and effectiveness of valve.
- *Optimal pressure gradients:*
  - Ankle—18 mm Hg.
  - Calf—14 mm Hg.
  - Knee—10 mm Hg.
- *Indications:*
  - Limb edema
  - Chronic peripheral venous insufficiency.
  - Varicose vein
  - Lymphedema
  - Deep vein thrombosis (DVT)
  - Phlebitis
- *Available range:* 10–15 mm Hg and 15–20 mm Hg.
- *Wearing duration:* Full day.

PNEUMATIC COMPRESSION DEVICE (FIG. 6.4)

Fig. 6.4 Pneumatic compression device (PCD)

- A external compression device that improves venous circulation.
- *Two types:*
  1. *Intermittent PCD:* Alternate inflation and deflation squeezes the blood proximally and replenishes that improves circulation.
  2. *Sequential PCD:* Distal to proximal milking effect.
- *Pressure range:* 19–150 mm Hg (Commonly used—30–50 mm Hg)
- *Indications:*
  - Prolonged recumbent patient.
  - Postoperativel condition like THR, TKR.
  - Venous disorders.

TRIFLOW INCENTIVE SPIROMETER (FIG. 6.5)

- A medical device used by the patient for improving their lung function.
- *Principle:* Opening of deflated alveoli of lungs under forced inspiration.
- *How to use:* Breath in from the device as slowly and as deeply as possible and hold the breath for 2–6 seconds.

Fig. 6.5 Triflow incentive spirometer

- *Indicators balls:* Provide a gauge, which indicates functioning of lung.
- *Indication:*
  - For recumbent patient.
  - After chest surgery.
  - After transthoracic surgery.

VACUUM-ASSISTED CLOSURE (VAC) DEVICE: GS KULKARNI MACHINE FOR VACUUM-ASSISTED DRESSING (FIGS 6.6A AND B)

- A method to accelerate the healing of wound using negative pressure.
- *Principle:*
  - Sealed moist environment with negative pressure
  - Subsidence of swelling and increased blood circulation
  - Angiogenic factor and fibroblast growth factor
  - Granulation tissue formation
  - Epithelization from edge of normal skin.
- *Components of VAC dressings:*
  - Sterilized foam completely covering the base of wound-two types
    - Polyurethane foam—pore size 400–600 nm—used for fresh traumatic wound
    - Polyvinyl alcohol foam—pore size 250 nm—used for nonhealing wound and ulcers.
  - Adhesive transparent dressing.

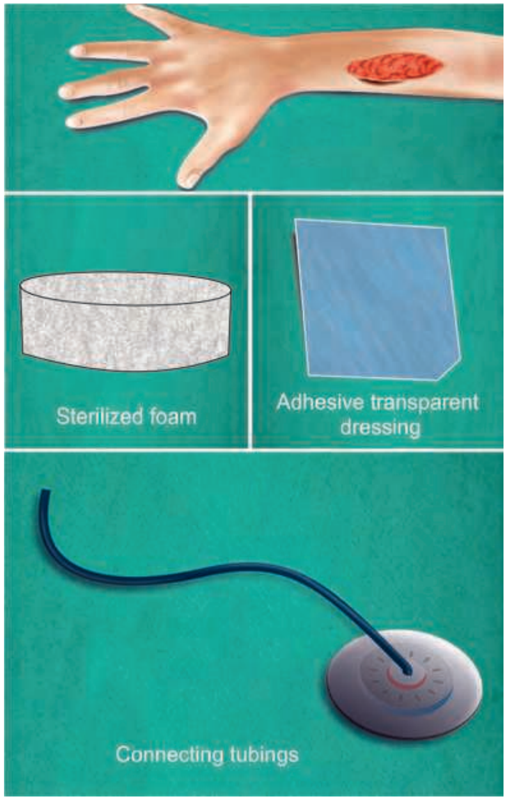


Fig. 6.6A Components of vacuum-assisted closure (VAC) device

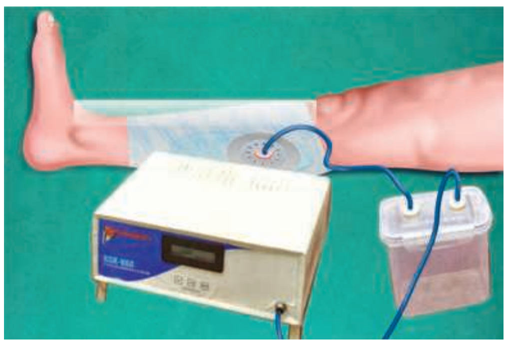


Fig. 6.6B GS Kulkarni machine for vacuum-assisted dresssing

  - Tubings (noncollapsible fenestrated tubing and connective tubing).
  - Negative pressure unit.
- *Pressure:* 50–200 mm Hg (commonly used—125 mm Hg)

- *Changing of vac dressing:*
  - After 48–96 hours.
  - Delayed in skin grafting.
- *Advantages:*
  - Increase rate of wound healing.
  - Decreased hospital stay.
  - Decreased number of dressings.
- *Indications:*
  - Any wound requiring secondary healing.
  - Open fracture.
  - Insufficient soft tissue coverage.
  - Tissue defects following musculoskeletal tumor surgery.
  - Unhealthy split thickness graft.

SURGICAL DRAIN (FIGS 6.7A AND B)

- Drain provides a pathway by which body fluid may trickle down to the surface even after closing the main wound.
- *Principle of drain application:*
  - Use a separate skin incision for drain in anatomically safe area.
  - Use shortest pathway for drain application.
  - Keep the end of drain in dependent part of wound or cavity.
  - Try to hold the drain with adjacent skin with suture material.
  - Drain should removed after 24–48 hours of its application.
- *Advantage of drain application:*
  - Act as a exit channel for collection around surgical planes or cavity.
  - Promote healing of surgical wound.
  - Give an alarming sign if any abnormal leak such as fresh bleeding, etc.
  - Sometimes provide a tract for wound irrigation.
- *Disadvantage of drain application:*
  - An additional source of infection.
  - A separate incision.
  - Risk of sinus or pocket formation.
  - Suture may break if drain is put near suture line.
- *Closed wound suction set/Negative suction drain (Romovac):*

Fig. 6.7A Negative suction drain

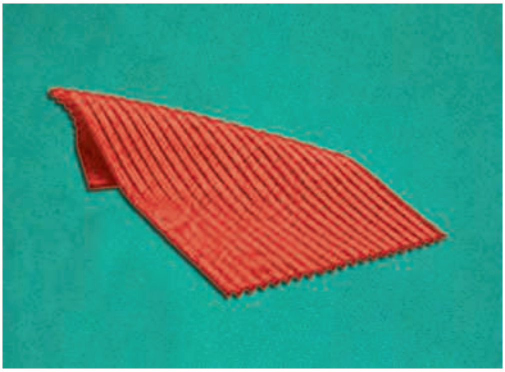


Fig. 6.7B Corrugated rubber drain

  - Component of Romovac drain system:
    - Below-container
    - Connecting tube with clamp and Y connector
    - Curved needle attached with catheter
    - Spare perforated catheter

- Features of Romovac drain:
  - Graduated below informs about volume of drained fluid.
  - Multiperforated catheter is lined with radiopaque material throughout its length.
  - Connecting tube is free from kink.
  - It produces 75 mm Hg of suction pressure when fully charged.
- *Common availability:*
  - Available in sizes of 14, 16, 18 French gauge of capacity 800 mL.
  - Minivac in sizes of 8, 10 French gauge of varying capacity.
- *Contraindication of negative suction drain:*
  - If bone grafting is done.
  - Local application of drugs such as depomedrol.
  - Antibiotic impregnated beads placed at operative site.
  - If dural tear has occurred during spine surgery.
- *How one can say that drain has served its purpose?*
  - If the content of drain is static on subsequent visit.
  - If column of fluid in tubing is permanently broken.
  - If the color of fluid is changed due to hematin formation.
  - Slight to and fro movement of tubing in body part may help in dislodgment of the clot if any.

• *Corrugated rubber drain:*
  - Made up of red (latex) rubber.
  - *Principle:* Capillary action assisted by gravity.
  - Available in sheet form.
  - It can be sterilized by autoclaving.

FOLEY'S CATHETER WITH UROBAG (FIGS 6.8A AND B)

Fig. 6.8A Foley's catheter with urobag

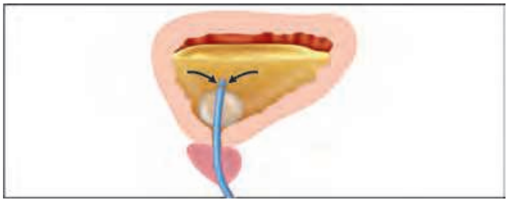


Fig. 6.8B Inflated in Foley's catheter in bladder

- Made up of latex rubber
- *Two types:*
  1. *Two way: having*
     a. *Main channel:* For drainage for urine
     b. *Balloon channel:* Connected with valved balloon for water retention.
  2. *Three way:* Above plus third channel for irrigation.
- *Capacity of bulb:* 30–50 mL (written over water channel)
- *Liquid to be used for balloon inflation:*
  - Normal saline or distilled water
  - Why not air?—End of urine draining channel will float above urine and hence there is no drainage through urine channel.
- *Bladder washing:* Always do with diluted betadine solution otherwise irritant effect.
- Urobag capacity—2 liters.
- Graduation over urobag as— 100, 500, 1000, 1500, 2000 mL.
- *What should we do if catheter removal become impossible?*
  - Over distend the bulb to rupture.
  - Inject paraffin through main drainage channel not ether because ether have corrosive effect over mucosa of bladder.
  - Cut proximal to valve and aspirate fluid directly from the balloon channel.

- Cut catheter 4 cm from external meatus and puncture balloon with stylet through balloon channel.
- Direct suprapubic puncture of inflated balloon chamber with 19 gauge spinal needle.
- Ultrasound guided suprapubic puncture of inflated balloon with needle.

INTERCOSTAL DRAINAGE (ICD)/ CHEST TUBE (FIG. 6.9)

Fig. 6.9 Intercostal drainage (ICD)/chest tube

- Made up of polyvinyl chloride (PVC) or soft silicone.
- *Components:*
  - Chest tube
  - Water seal
  - Reservoir
- *Function of water seal:*
  - Act as one way valve that allow air or gas to escape from pleural cavity but prevent their re-entry into pleural cavity.
- *Site of chest tube application:*
  - 4th and 5th intercostal space in mid-clavicular line.
  - Boundary of triangle of safety:
    - Anterioly—serratus anterior
    - Posteriorly —latissimus dorsi
    - Inferioly—5th rib.
- *Common indication:*
  - Drainage of fluid or air from pleural cavity such as pleural effusion, hemothorax, chylothorax, pyothorax, pneumothorax, hydropneumothorax, etc.
  - After transthoracic surgery
- *Contraindication:*
  - Diaphragmatic hernia
  - Refractory coagulopathy.
- *Available sizes:*
  - Adults = 20–40 FG (French gauge)
  - Children = 6–26 FG

DIFFERENT PARENTERAL FLUIDS (FIG. 6.10)

Fig. 6.10 Different parenteral fluids

- *Normal salive (0.9 %):* Available in 100, 250, 500, 1000, 2000 mL container
- Dextrose (5%, 10%, 25%, 50%)
- DNS (5% glucose + 0.9% saline)
- *Ringer lactate (RL):* Electrolyte concentration same as plasma.
- *Plasma expanders:*
  - Polygeline (Hemaccel)
  - LMW (Dextrose) molecular weight—40000
- *Mannitol (20%):* Available in 100, 350 and 500 mL capacity.

BLOOD AND BLOOD PRODUCTS (FIG. 6.11)

- Whole blood
- Packed cells concentrate (RBC)
- Plasma.
- Platelet concentrate.

Fig. 6.11 Blood and blood products

INTRAVENOUS DRIP SET (FIGS 6.12A TO C)

- *Parts of IV drip set:*
  1. Spike cover
  2. Spike—14.3 mm
  3. Air inlet and air filter
  4. Murphy drip chamber—50 mm
  5. Solution filter
  6. PVC tube—150 cm
  7. Roller clamp
  8. Injection set
  9. Connector
  10. Needle.
- *Microdrip or pediatric drip set or burette infusion set:* Here a calibrated drip chamber of capacity 100 mL/150 mL is attached and two roller clamp one proximal and another distal to drip chamber are adjusted.
- *Blood transfusion (BT) set:* Here a filter of pore diameter 170 µm (most common) is adjusted in drip chamber and the needle provided with BT set is of 18 gauge.
- *Changing time of IV drip set:* Change at every 72 hours but in cases of blood products, change it in every 12 hours.
- *Measurements:*

15 normal drops	1 mL
60 micro drops	1 mL
4 micro drops	1 normal drop

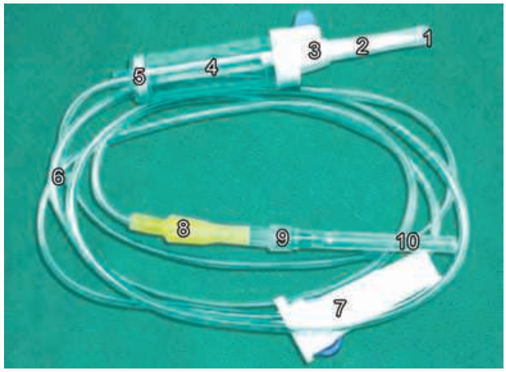


Fig. 6.12A Intravenous drip set

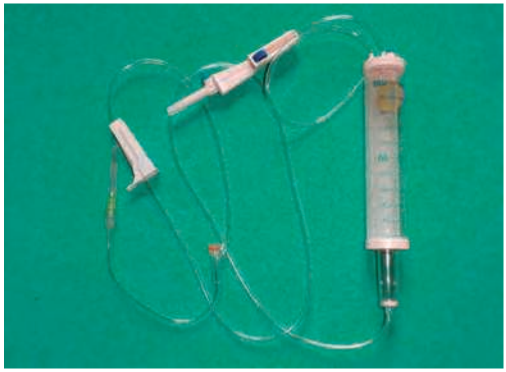


Fig. 6.12B Pediatric drip set

Fig. 6.12C Blood transfusion (BT) set

INTRAVENOUS CANNULA (FIG. 6.13)

- *Parts of IV cannula:*
  1. Needle
  2. Catheter
  3. Bushing
  4. Valve
  5. Catheter hub and wings
  6. Injection port cap
  7. Luer connector
  8. Needle grip

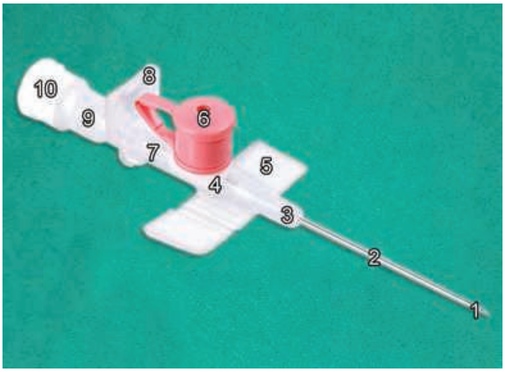


Fig. 6.13 Intravenous cannula

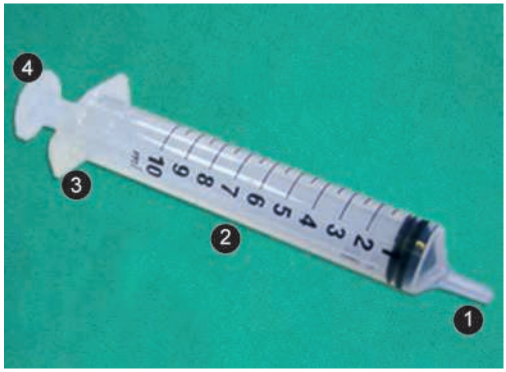


Fig. 6.14A Disposable syringe

9. Flash back chamber
10. Luer lock plug.

- Color coding and cannula diameter in French gauge (1 FG = 0.33 mm or 3 FG = 1 mm)

Color coding	*Cannula diameter in French gauge*
Orange	14 G
Gray	16 G
Green	18 G
Pink	20 G
Blue	20 G
Yellow	22 G
Violet	24 G

- *Sites of peripheral cannulation:* Superficial veins of forearm, elbow, dorsum of hand, dorsum of foot, leg and neck.
- *Indication for changing of IV cannula:*
  - Accidental dislodgment
  - Infection
  - Phlebitis
  - Occlusion.

☑ *Note: Alternative way of IV infusion:*
  - Venesection—in long saphenous vein and cubital vein
  - Central line—in subclavian vein or internal jugular vein.

SYRINGE AND NEEDLE (FIGS 6.14A TO C)

- Syringes are made up glass or plastic.

Fig. 6.14B Bladder washing syringe

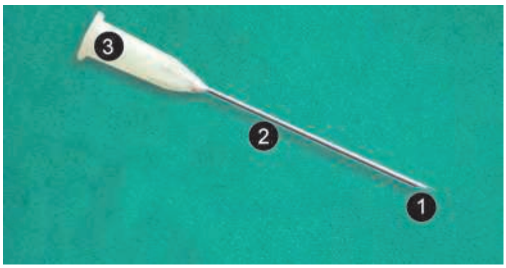


Fig. 6.14C Hypodermic needle

- *Parts of syringe:*
  1. Tip
  2. Barrel
  3. Plunger
  4. Finger grip
- *Parts of needle:*
  1. Beveled tip
  2. Shaft
  3. Hub opening

- *Uses:*
  - For intramuscular and intravenous injection.
  - For withdrawal of blood or cerebrospinal fluid (pediatrics) sampling.
  - For aspiration of joint or cavity.
  - For fine needle aspiration (22 G) biopsy.
- Syringes are commonly available in capacity of 2 mL, 5 mL,10 mL, 20 mL, 50 mL and 100 mL.
- Hypodermic needles are available in French gauge ranging from 14 to 30. Color coding for needles are different from IV cannula.

SEGREGATION OF BIOMEDICAL WASTE (FIGS 6.15A AND B)

- Biomedical waste are segregated according to their source of origin in four types colored container and treated as follows:
  - *Yellow plastic bag:* Infectious wastes, bandages, gauges, cotton or any other items in contact with body fluids, human body parts, placenta: treatment is done by incineration.
  - *Red plastic bag:* Plastic waste such as gloves, catheters, injections, syringes, tubings, IV drip sets bottles, blood bags: treatment is done by shredding/ autoclaving/microwaving.
  - *Blue plastic bag:* Sharps such as needles, glasswares, broken glass article, scalpels, blades: treatment is done by autoclaving/ destruction/land filling.
  - *Black plastic bag:* General waste such as papers, cardboard, foils, plastic wrappers, waste food items, file folders: land filling

CHECKLIST FOR POSTOPERATIVE ROUND

- Level of consciousness of patient.
- Vital status of patient.
- Any new symptoms or sign of improvement or deterioration.
- Limb position (limb elevation or abnormal attitude of limb).
- Inspection of operative site (like soakage)
- Fluid input and urine output.
- Oral or parental nutrition of patient.
- Drugs being given to the patient.
- Documentation.

CHECKLIST FOR PREPARATION OF WARD ROUND

- Neat and clean linen and patient clothing.
- Complete history and examination of patient.
- Patient attitude and limb position.
- Casting of limb if any.
- Dressing of wound.
- Culture and sensitivity record.
- Traction if any.
- Care of tubing such as Foley's catheter, suction drain, chest tubes, etc.
- Lab investigation and radiographs.
- Fluid and drugs being given to patient.
- Documentation in patient file.

☑ *Note: Victorian ward*—As name suggests these wards were come in existence in period of Queen Victoria. There were large halls in which beds were arranged in two long rows.


A

B

Figs 6.15A and B Segregation of biomedical waste

SECTION

2

Table of Instruments and Implants

Upendra Kumar

Chapters

PICKING OF INSTRUMENTS AND IMPLANT

- Proceeding on instrument and implant table:
  - You may ask to pick an instrument or implant or both.
  - Examiner himself/herself may throw some instrument or implant towards you.
- Examiners expectation in this section:
  - Full name of instrument or implant.
  - Parts of instrument.
  - Dimension of implant.
  - How and where to use the particular instrument?
  - Indication to use the specific implant.

CHAPTER

7

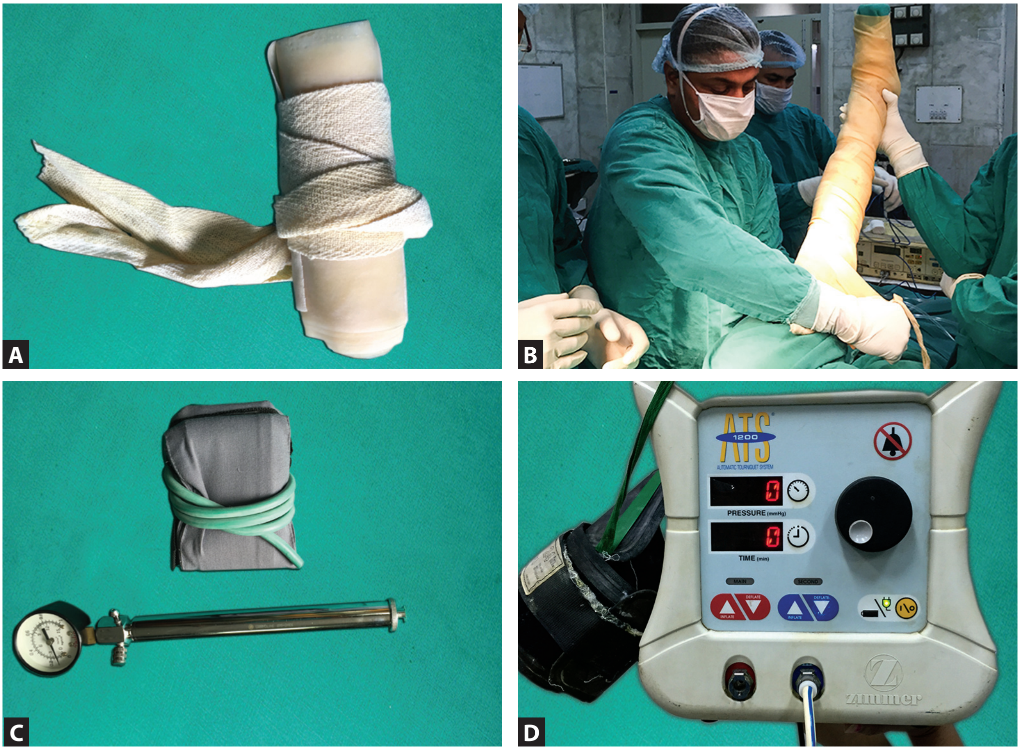
Tourniquet and Esmarch's Bandage

TOURNIQUET AND ESMARCH'S BANDAGE (FIGS 7.1A TO D)

- The term tourniquet was cited by Petit (1718) but credit for invention of pneumatic tourniquet is gone to Harvey Cushing (1904).
- A tourniquet is a constricting or compressing device used to control venous or arterial circulation to an extremity for a period of time.
- *Action:*

  Constrict the vessel of limb
  ↓
  Prevents blood flow to limb
  ↓
  Make surgical field bloodless
- *Benefits of tourniquet application:*
  - Increase tissue recognition hence precision of surgery is improved.
  - Prevents tissue trauma due to repeated mopping of surgical site.
  - Decrease the surgical time thus, chances of infection is minimized.
- *Classification:*
  - Nonpneumatic
    - Nonelastic belt.
    - Elastic esmarch.
  - Pneumatic
    - Nonautomatic or manual.
    - Automatic.

Brunner's ten rule of tourniquet application; modified by Braithwaite and Klenerman	
• Limb status	Healthy limb, in unhealthy limb use cautiously
• *Size:*	
– Width of cuff	For arm 10 cm or more than 20% diameter of upper limb and for thigh 15 cm or more than 40% diameter of thigh
– Length of cuff	15–107 cm
• *Site of application:*	
– For upper limb	Arm
– For lower limb	Thigh
• Padding	Two layers of cotton
• *Pressure:*	
– For upper limb	Systolic pressure + (50–100) = 200–250 mm Hg
– For lower limb	2 × systolic pressure = 250–350 mm Hg
• Time	Not more than 2 hour, absolute maximum is 3 hours
• Temperature	Moist environment
• *Documentation:*	
– Checking of pressure calibration	Weekly
– Maintenance of tourniquet system	3 monthly



Figs 7.1A to D Tourniquet and Esmarch's bandage. (A) Esmarch's bandage; (B) Limb exsanguination; (C) Pneumatic tourniquet (manual); (D) Pneumatic tourniquet (automatic)

- *Esmarch's bandage:*
  - It is a strip made-up of red rubber fitted with two tapes at one end.
  - It is 4.5’ wide and 2 meter long.
  - Put the tape end of bandage inside during rolling it.
  - The latex free sterilizable Esmarch's bandages are also available in different sizes (3”,4”,6” × 9,12,15 feet).
- *Component of pneumatic tourniquet:*
  - Cuff
  - Tubing
  - Microprocessor controlled source with display.
- *Perquisite of tourniquet application:*
  - Keep limb elevated for a minimum of 5 minutes.
  - Do exsanguination of limb from distal to proximal if not contraindicated.
- *Contraindication of exsanguination:*
  - Peripheral arterial disease
  - Severe crush injury
  - Sickle cell disease
  - Malignant tumor.
- *Contraindication of tourniquet application:*
  - Deep vein thrombosis (DVT)
  - Infection

- *Complications of tourniquet application:*
  - *Complication at tourniquet site:*
    - Skin abrasion.
    - Chemical burn—due to inflow of solution underneath the tourniquet.
  - *Complication related to operative site:*
    - Intraoperative bleeding—due to venous congestion.
    - Swelling—due to reactive hyperemia.
    - Post-tourniquet bleeding.
  - *Vascular system-related complication:*
    - Compartment syndrome—due to microvascular blockade.
    - Pulmonary embolism.
    - Deep vein thrombosis.
    - Reperfusion injury—due to redistribution of blood in ischemic area.
  - *Other complications:*
    - Myonephrotic metabolic syndrome (metabolic acidosis, hyperkalemia, etc.)—due to toxic metabolites.
    - Post-tourniquet syndrome of Bunnell (swelling, stiffness, numbness, etc.)—due to longstanding ischemia.
    - Tourniquet paralysis syndrome (neuropraxia)—due to demyelination.
    - Spread of tumor and infection.
    - Rhabdomyolysis—may lead to renal failure.

CHAPTER

8

General Surgical Instruments

TOWEL CLIPS (FIG. 8.1)

- *Commonly used towel clips:*
  - Mayo's towel clip
  - Backhaus's towel clip
- *Mayo's towel clip:*
  - Small, curved and sharply pointed blades.
  - Given with catch-lock mechanism.
- *Uses of towel clips:*
  - For firmly holding the towels during surgical drapping.
  - For holding the suction tubes, wires of cautery, cables of arthroscope, etc. over sterile drapping.
  - For holding the fractured ribs in cases of flail chest or stove-in chest injury.

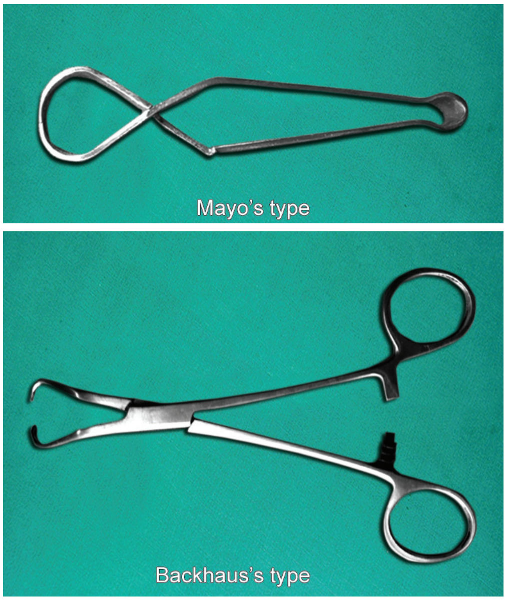


Fig. 8.1 Towel clips

BARD-PARKER KNIFE HANDLE WITH DETACHABLE BLADE (FIGS 8.2A AND B)

- *Commonly used surgical blades are:*
  - 23 no—leaf shaped curved cutting edge with flat unsharpened back edge. Used for skin incision.
  - 15 no—curved cutting edge with an unsharpened back edge. Used for inner dissection.
  - 11 no—triangular blade with sharp pointed and flat cutting edge. Used for making stab incision wherever required, e.g. for arthroscopy portals.
- *Methods of holding scalpel are:*
  - Pen holding position—grip is firm and controlled. Used for delicate dissection. Most commonly practiced position.
  - Fiddle-bow position—grip is neither firm nor controlled.

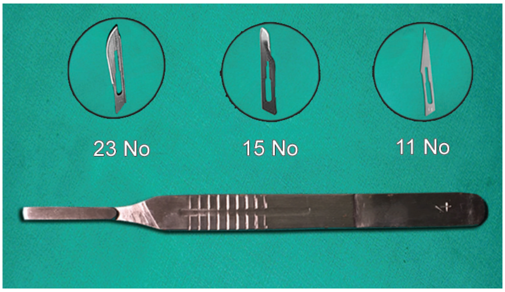


Fig. 8.2A Bard-Parker knife handle with detachable blade

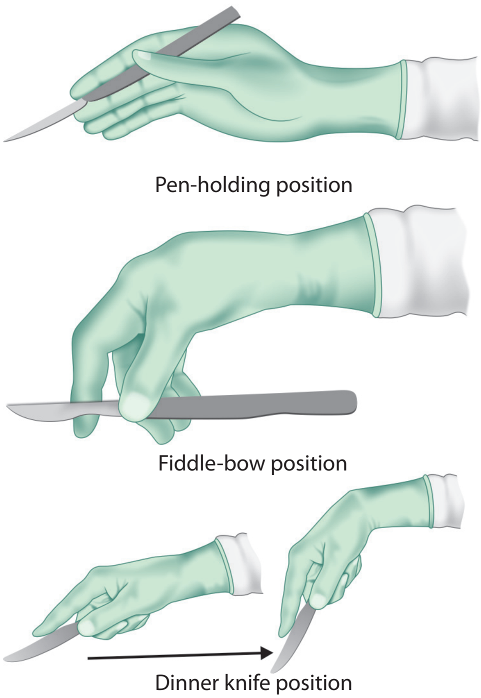
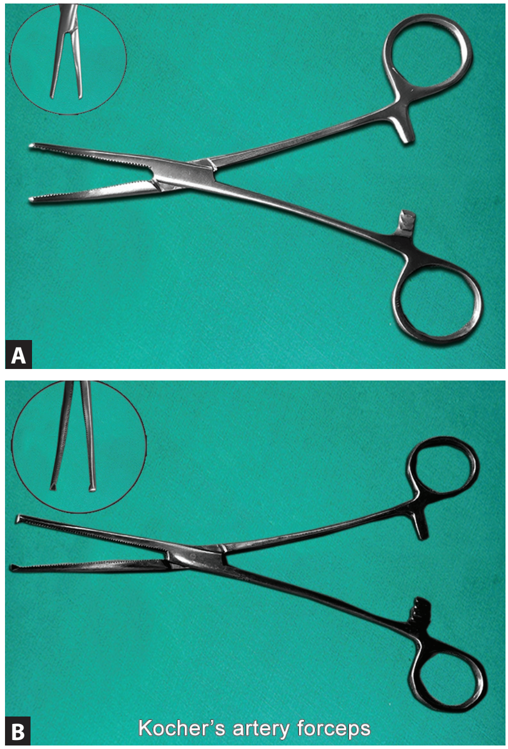


Fig. 8.2B Method of holding scalpel

- Dinner knife position—used for long and deep incision.

ARTERY (HEMOSTATIC) FORCEPS (FIGS 8.3A AND B)

- Conical and blunt tipped blades with serrated inner margins.



Figs 8.3A and B Artery (hemostatic) forceps

- Given with catch lock.
- *Artery forceps may be classified as:*
  - Small (mosquito), medium, large
  - Straight or curved
  - Nontoothed or toothed (e.g. Kocher's or Lane's artery forceps)
- *Uses:*
  - Used as hemostat.
  - Used for blunt dissection.
  - To hold the cut edge of fascia or aponeurosis, etc
  - To open the abscess cavity (Hilton method).
  - Used for holding the suture end and knot.

ALLIS FORCEPS (FIG. 8.4)

- Straight blades with sharp interlocking teeth
- Fitted with catch-lock system.

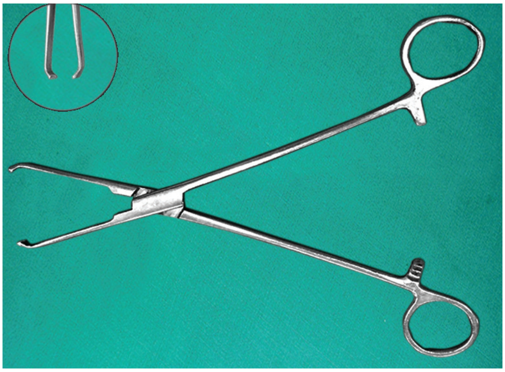


Fig. 8.4 Allis forceps

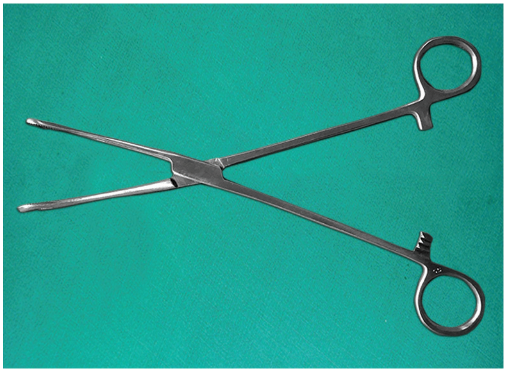


Fig. 8.5 Rampley's sponge holding forceps

- *Uses:* Used to hold tough structures such as skin, fascia, capsule, etc.
- Lane's tissue holding, Babcock's tissue forceps, vulsellum and tenaculum some other tissue holding forceps.

RAMPLEY'S SPONGE HOLDING FORCEPS (FIG. 8.5)

- It has 9.5" long fenestrated and serrated blades.
- Given with catch-lock mechanism.
- *Uses:* For cleaning and painting at surgical sites.

CHEATLE'S FORCEPS (SISTER'S FORCEPS) (FIG. 8.6)

- It has curved and serrated blades.
- No locking system.
- It resembles the beak of Cheatle.
- *Uses:*
  - To take sterile instruments, dressing, towels from surgical drum.
  - To take instruments out from Cidex tray.

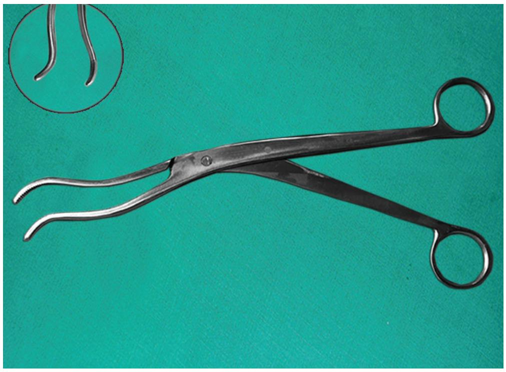


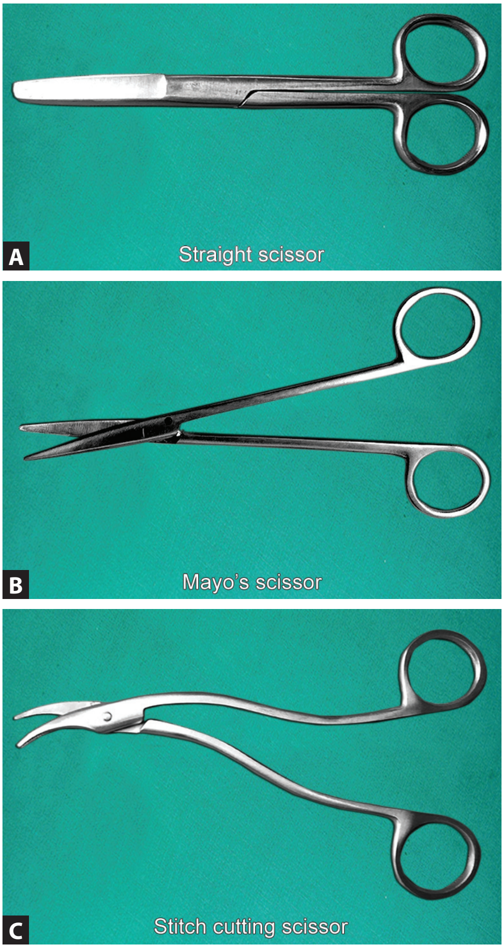
Fig. 8.6 Cheatle's forceps (sister's forceps)

SCISSORS (FIGS 8.7A TO C)

- Its blades are provided with sharp margin having pointed or blunt tip.
- No locking mechanism.
- It may be straight or curved.
- *Uses:*
  - Used for sharp dissection around neurovascular bundles.
  - Used for blunt dissection around sheathed structure.
  - Used to dissect tough structure such as fascia, aponeurosis, capsule, etc. in place of scalpel.

Method of using stitch cutting scissor (Fig. 8.7D).

Staple remover is used for surgical staples (Fig. 8.7E).



Figs 8.7A to C Scissors

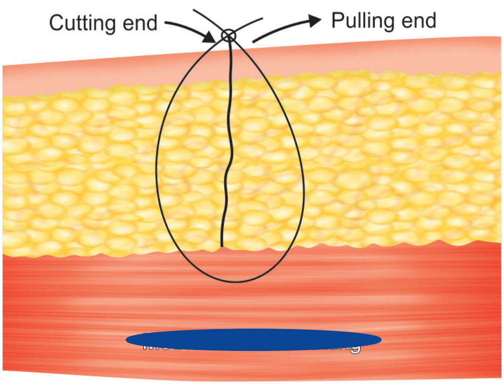


Fig. 8.7D Methods of stitch cutting

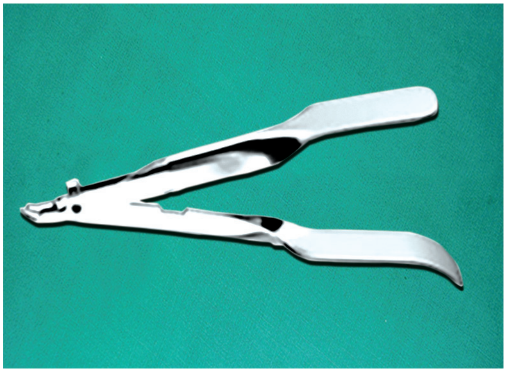


Fig. 8.7E Stapler remover equipment

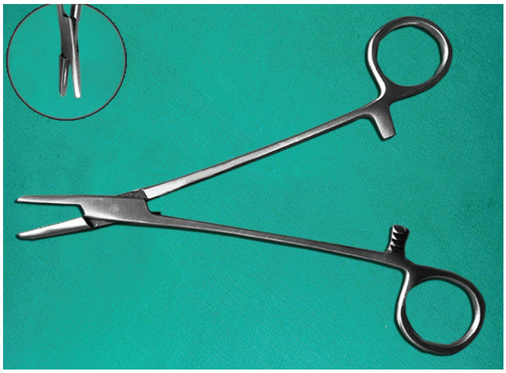
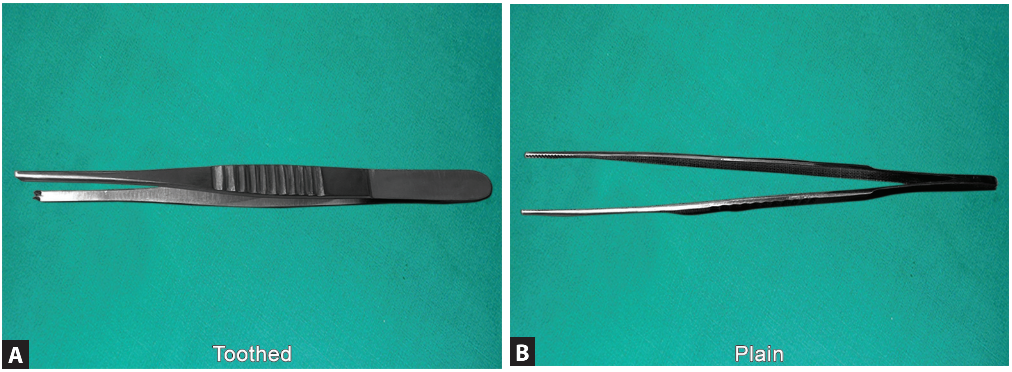


Fig. 8.8 Needle holder

NEEDLE HOLDER (FIG. 8.8)

- It has smaller blades with serrated inner surfaces.
- It has small longitudinal groove to hold the shaft of needle.
- Attached with locking mechanism.
- How to hold needle holder?
  - Needle holder should hold between thumb and ring finger.
  - Hold the needle at junction of its anterior 1/3rd and posterior 2/3rd; if it is hold too anterior there is no enough space over needle to come out from tissue or if it is hold too posterior there is chances of breakage of needle because it is weakest part of needle.



Figs 8.9A and B Dissecting forceps

DISSECTING FORCEPS (FIGS 8.9A AND B)

- It has two limbs which are fused at one end and free at another.
- Provided with horizontal ridges to make the grip firm.
- Fused end provides the spring action.
- *Free ends may be:*
  - Plain or
  - Toothed (**Victor boney**)
- *Uses:*
  - *Toothed:* To hold the tough structures such as skin, fascia, capsule, etc.
  - *Plain:* To hold the delicate and friable structure such as vessel, bowel, etc.

CHAPTER

9

Surgical Retractors and Bone Levers

LANGENBECK'S RIGHT ANGLE RETRACTOR (FIG. 9.1)

- *Parts:*
  - Handle—long
  - Solid blade right angle to handle
- *Variations:* Single or double bladed, small or long bladed, narrow or wide bladed
- *Uses:* For superficial or deep retraction.

CZERNY'S RETRACTOR (FIG. 9.2)

- *Parts:*
  - *Body:* With elliptical hole to make it light
  - *Two ends:* One with small solid blade and another with biflanged hook; hooks and blades are positioned in opposite direction.
- *Uses:* Blade end is used for superficial retraction and biflanged hook is used for retraction in deep spaces where blade end cannot be inserted, e.g. for last deep stitch.
- **Morris' retractor** is same as Czerny's retractor except its blade which is convex from inside and concave from outside.

HOOK RETRACTORS (FIG. 9.3)

- *Parts:*
  - Handle
  - Sharp and forged hook
- *Types:* On the basis of numbers hook

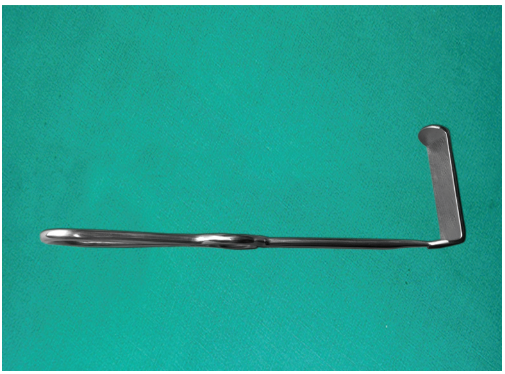


Fig. 9.1 Langenbeck's right angle retractor

Fig. 9.2 Czerny's retractor

- Single hook retractor
- Double hook retractor
- Multiple hook (Cat's paw or **Volkmann's**) retractor

- *Uses:* Used for superficial retraction specially for tough structures like skin, facia of sole and palm.
- ***Sen Miller retractors*** have solid body with a Volkmann's hook at one end and Langenbeck's right angle blade at another end.

Fig. 9.3 Hook retractors

HOHMANN'S RETRACTOR (FIG. 9.4A)

- *Parts:*
  - *Handle:* With one or two hole to make it lighter
  - *Flattened blade with hook:* To retract the soft tissue against bony point.
- *Variation:* Narrow or wide, pointed tip or blunt tipped, small tip or long tipped, bent at variable angle.
- *Uses:* Can be used like any other retractors but its specific indication are:
  - To retract the tissue at the margins of joint, e.g. total knee arthroplasty.
  - To retract the tissue around acetabulum, e.g. total hip arthroplasty.
- *Cobra **(Aufranc)** retractor (Fig. 9.4B):* These retractors are similar to Hohmann's retractors with some modifications:
  - A blade just like hood of snake cobra.
  - Serrated tip appears to be head of cobra.
  - Stout handle (sometime).

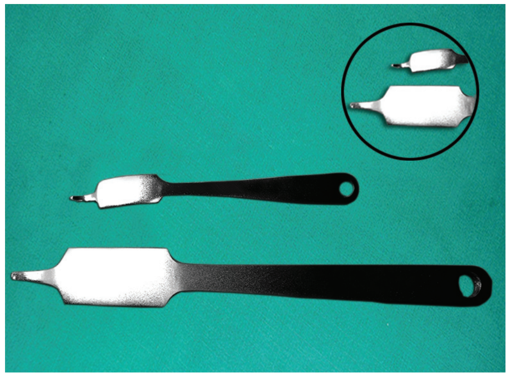


Fig. 9.4A Hohmann's retractor

Fig. 9.4B Cobra retractor

LANE BONE LEVER (FIG. 9.5A)

- *Parts:*
  - Handle with a ring
  - A blade with variation like
    - *Straight or curved:* Curved levers confines the curvature of bone.
    - *Smooth or serrated:* Serrated levers prevent the slippage over periosteum
- *Uses:* Retraction of soft tissue during surgeries over long bone.
- ***Trethowan** bone lever (spike):* It is similar to Lane bone lever but having a long blade with a hook at one end and ring at another (Fig. 9.5B).

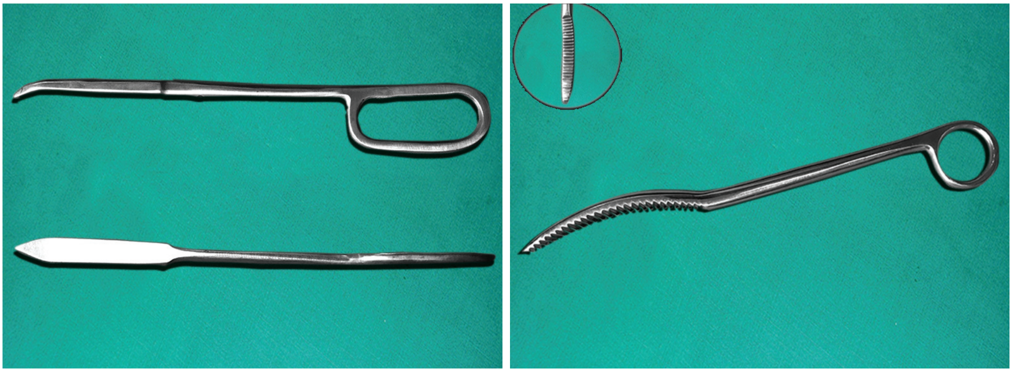


Fig. 9.5A Lane bone lever

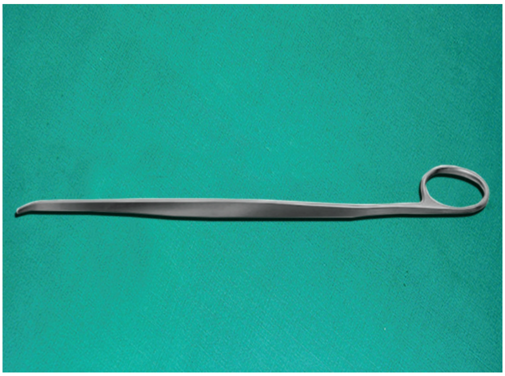


Fig. 9.5B Trethowan bone lever (spike)

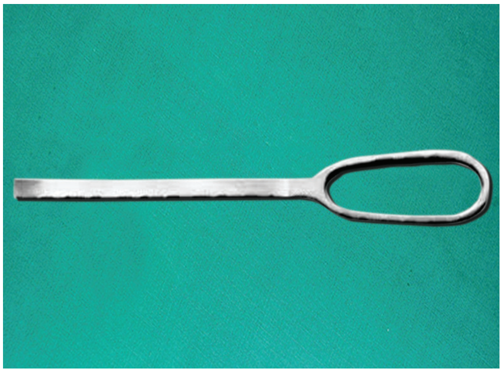


Fig. 9.6 Bristow's retractor

BRISTOW'S RETRACTOR (FIG. 9.6)

- *Parts:*
  - Handle with a oblong ring
  - A long blade with curved beveled end.
- *Uses:* Retraction of soft tissue during surgeries over long bone.

CHAPTER

10

Bone Cutting and Related Instruments

OSTEOTOME (STILLE TYPE) (FIG. 10.1)

- *Part:*
  - Blunt flat top.
  - Handle.
  - Quadrangular shaft—flattened and both edges beveled.
- *Variations:* Straight and curved.
- *Uses:*
  - For cutting of bone.
  - For making osteoperiosteal flap and petalling.

BONE CHISEL (STILLE TYPE) (FIG. 10.2)

- *Part:*
  - Blunt flat top.
  - Handle.
  - Quadrangular shaft—flattened and one edge beveled.
- *Variations:* Straight and curved.
- *Uses:*
  - For removal of unwanted callus at non-union site.
  - For saucerization in chronic osteomye litis.

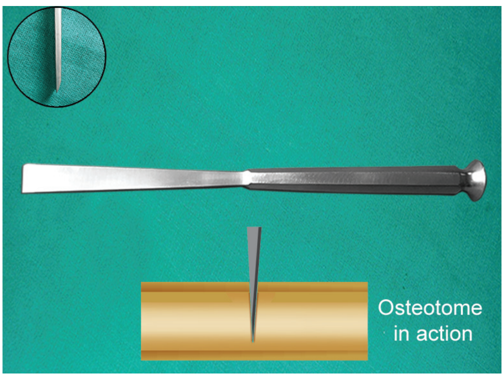


Fig. 10.1 Osteotome (Stille type)

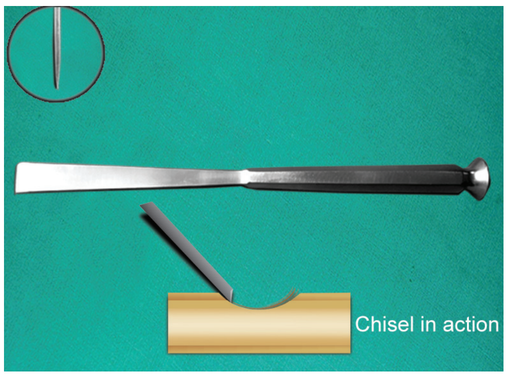


Fig. 10.2 Bone chisel (Stille type)

- Extraperiosteal resection of osteochondroma.
- For removal of excess bone over implant.

BONE GOUGE (STILLE TYPE) (FIG. 10.3)

- *Part:*
  - Blunt flat top.
  - Handle.
  - Curved blade with shap end.
- *Variations:* Straight and curved.
- *Uses:* For harvesting bone graft.

Osteotome, chisel and gouge are commonly available in fiber handle.

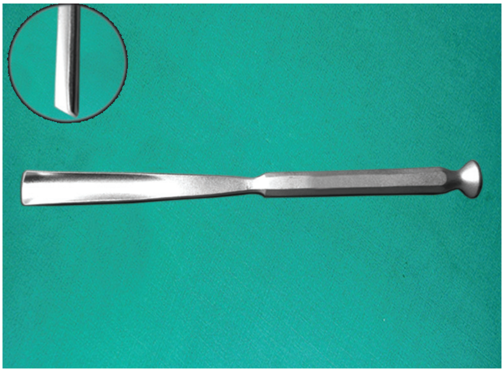


Fig. 10.3 Bone gouge (Stille type)

BONE CUTTER (FIG. 10.4)

- *Parts:*
  - Hand piece with spring action.
  - Hinge-single or double action.
  - Sharp cutting blades.
- *Variations:* Straight and curved.
- *Uses:*
  - For cutting of bone edges.
  - For making the bone graft in small pieces.
- ***Ruskin*** *type* and ***Liston*** *type* are famous bone cutter.

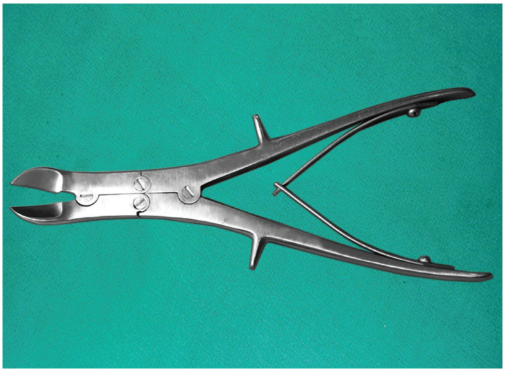


Fig. 10.4 Bone cutter

LAMINECTOMY FORCEPS (FIG. 10.5)

- It is a misnomer; it is a bone cutter not a forcep.
- *Parts:*
  - Hand piece with spring action.
  - Hinge-double action.
  - Sharp angled cutting blades (45° or 90°).
- Used for cutting of spinous process from lamina.
- **Stille-Horsley** and **Tudor-Edward** type lamina cutters are common variety.

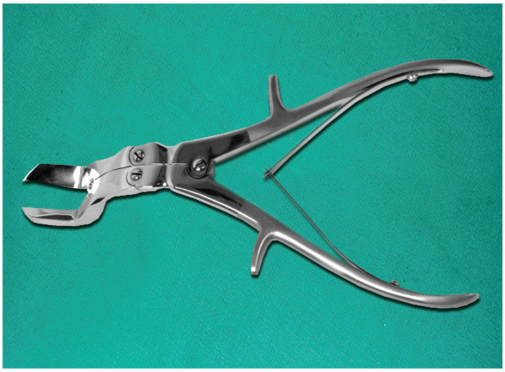


Fig. 10.5 Laminectomy forceps

BONE NIBBLER (RONGEUR) (FIG. 10.6)

- *Parts:*
  - Hand piece with spring action.
  - Hinge- single or double action.
  - Cupped blades with sharp edges.
- *Variation:* Straight or curved.
- *Uses:*
  - For smoothening the ends of bone.
  - For biting of excess bone.
  - For removal of unwanted fibrous tissue.
- **Stille-Horsley, Leksell, Sargent, Duckbill** are some famous Rongeurs.

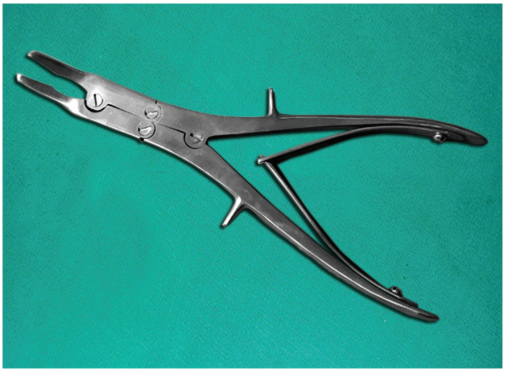
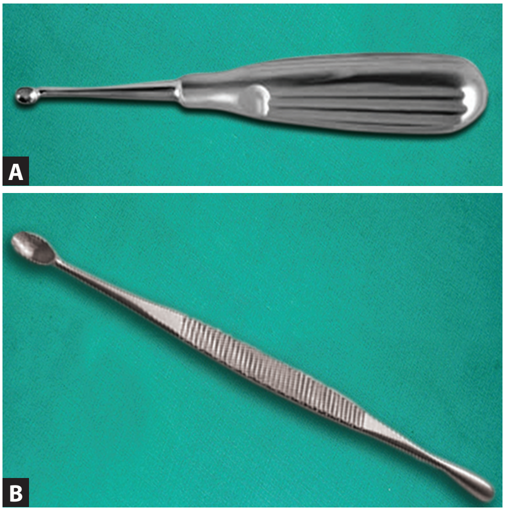


Fig. 10.6 Bone nibbler (Rongeur)

SCOOP OR CURETTE (VOLKSMANN'S TYPE) (FIGS 10.7A AND B)

- *Parts:*
  - Handle ribbed for good hold.
  - Sharp, edged and trough like end (one or both end).
- *Uses:*
  - Scrapping the wall of cavities of benign bone tumor.
  - Scrapping of osteomyelitis cavity.
  - To remove immature callus or fibrous tissues from neglected fracture ends.
  - Freshening of sinus or fistulous tracts.
  - Freshening of fracture ends.



Figs 10.7A and B Scoop or curette (Volksmann's type)

CORTICOTOME (FIG. 10.8)

- *Parts:*
  - Blunt flat end.
  - Handle.
  - Quadrangular shaft—flattened with double beveled **L**-shaped cutting edge.
- *Uses:* For subperiosteal low energy osteotomy of bone.

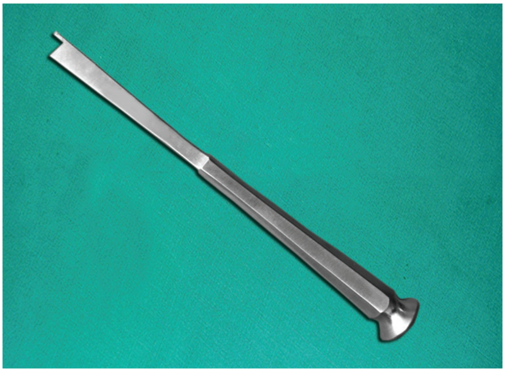
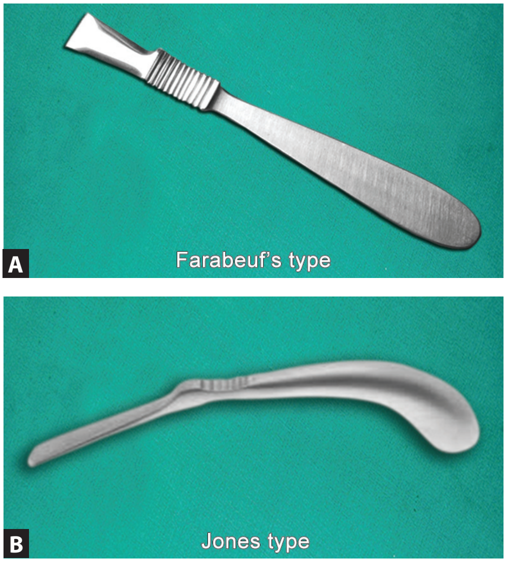


Fig. 10.8 Corticotome

PERIOSTEAL ELEVATOR (FARABEUF'S TYPE) (FIGS 10.9A AND B)

- *Parts:*
  - Handle.
  - Thumb rest.
  - Sharp beveled curved tip.



Figs 10.9A and B Periosteal elevator

- *Uses:* For raising the periosteum from bone.
- Why you elevate periosteum?
  - Periosteum is tough and slippery structure hence any instrument may slip over it.
  - Get a safer plane as neurovascular structures are retracted away along with periosteum.
  - Helps in reduction of displaced fracture.

☑ *Note:* **Jones** periosteal elevator not very common nowadays.

GIGLEY'S SAW (FIG. 10.10)

- *Components:*
  - Braided stainless steel wire with loop at ends.
  - Two hooks.
- *Uses:*
  - For amputation of limb.
  - Used for osteotomy like Salter's and McMurray's osteotomy.

AMPUTATION SAW (FIGS 10.11A AND B)

- *Two types:*
  1. Fixed bladed.
  2. Detachable bladed.

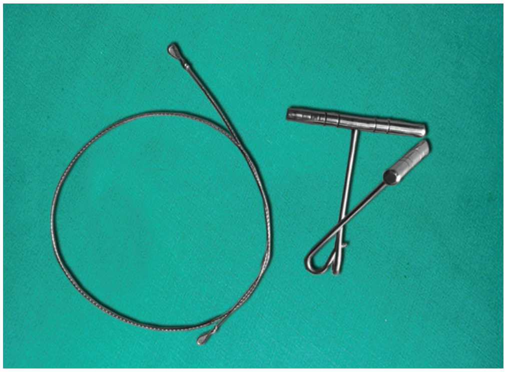
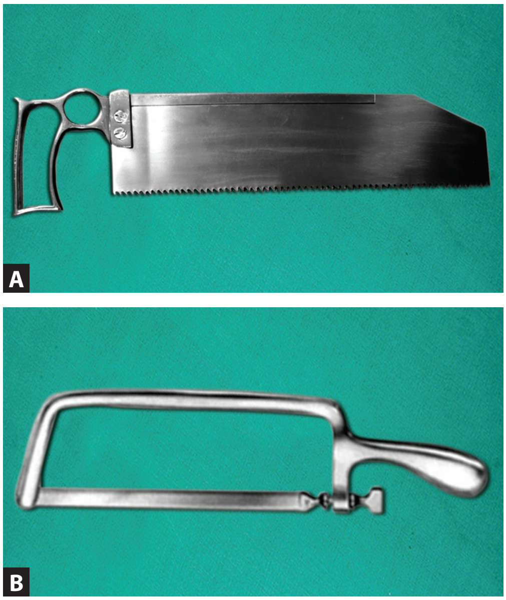


Fig. 10.10 Gigley's saw with hook



Figs 10.11A and B Amputation saw

- *Parts:*
  - Handle
  - *Fixed blade:* Rectangular blade toothed at one margin.
  - *Detachable blade:* C-shaped frame with blade attachment.
- *Use:*
  - For amputation of limb.
  - For removal of plaster cast.

CHAPTER

11

Bone and Plate Holding Instruments

BONE HOLDERS

- *Parts:*
  - Hand piece with or without locking system.
  - Hinge.
  - Bone holding blades.
- *Uses:*
  - Holding the bone for manipulation during reduction.
  - Steadies the bone during reaming, nibbling, drilling, etc.
  - It steadies reduced bone with plate also.

REDUCTION CLAMP/ FORCEPS (FIGS 11.1A TO C)

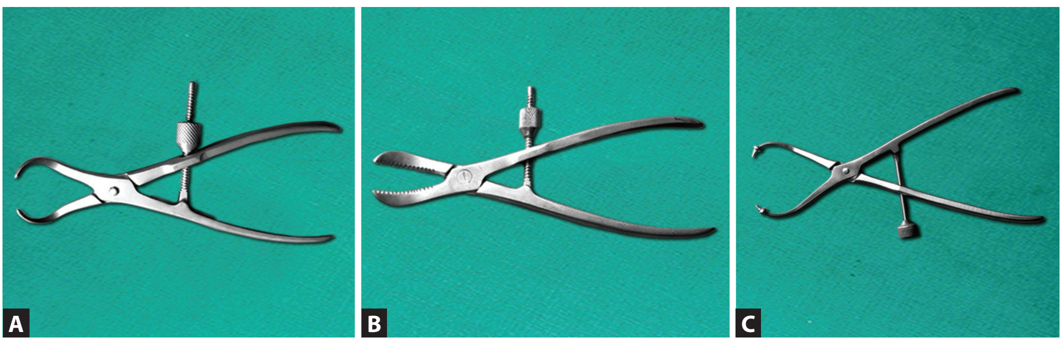
- Speed lock or catch-lock mechanism in hand piece.
- Blades are curved.
- *Variations:* Pointed, serrated or ball tipped.

HEYGROOVE'S BONE HOLDERS (FIG. 11.2)

- Speed lock mechanism is at top of hand piece.
- Bone holding blades are cylindrical, curved and serrated to accommodate the convexity of bone and to make grip firm.

LANE'S BONE HOLDERS (FIG. 11.3)

- With or without ratchet.
- Bone holding blades are rectangular, slightly curved, serrated and toothed to make grip more firm.



Figs 11.1A to C Reduction clamp/forceps

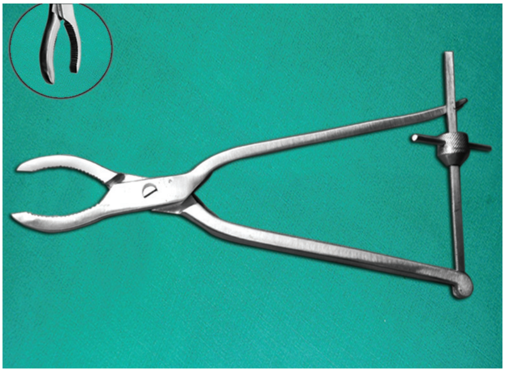


Fig. 11.2 Heygroove's bone holders

Fig. 11.3 Lane's bone holders

☑ *Note:* Bone holders, such as; **Kern** (straight blade) type, **Ferguson** (double row of tooth) type.

BURN'S BONE HOLDERS (FIG. 11.4)

- Catch-lock mechanism for locking.
- Blades are triangular, curved, serrated and with pointed tip having fenestration over it.
- Mainly used for radius, ulna, fibula.

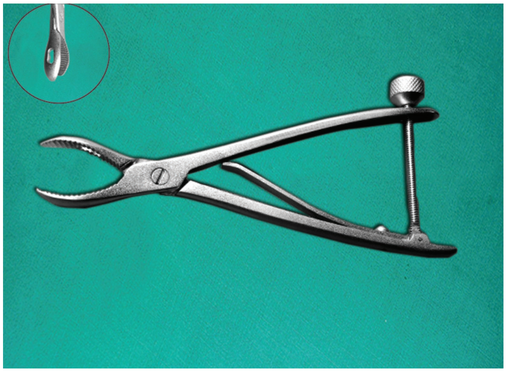


Fig. 11.4 Burn's bone holders

MANI'S CLAMP (FIG. 11.5)

- Speed locking mechanism in hand piece.
- Blades are rectangular, straight, serrated and toothed. Its inner surface is designed in such a way that plate is totally locked over reduced bone.
- Mainly used for radius, ulna, humerus, and fibula.

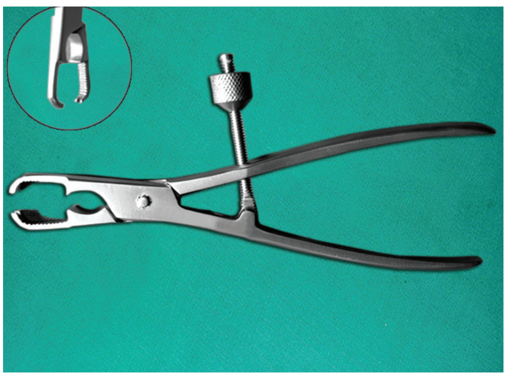


Fig. 11.5 Mani's clamp

LOWMAN'S CLAMP (FIG. 11.6)

- Opposing sets of incurving claws which can be screwed into a tight position.
- May be two pronged, three pronged, four pronged.

VERBRUGGE'S SELF-CENTERING BONE HOLDING FORCEPS (FIG. 11.7)

- Speed lock mechanism.

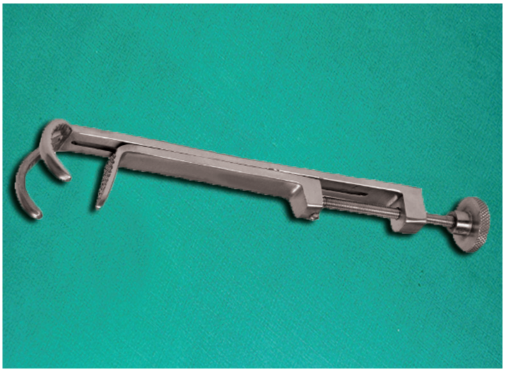


Fig. 11.6 Lowman's clamp

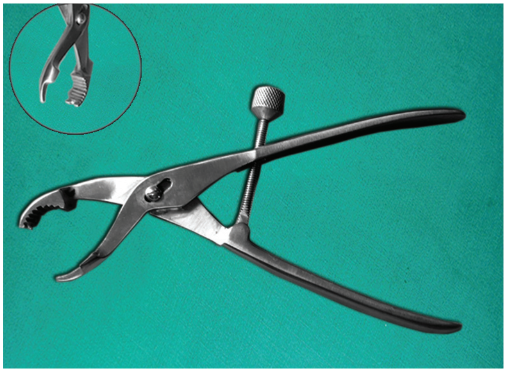


Fig. 11.7 Verbrugge's self-centering bone holding forceps

- Self-centering hinge.
- Out of two curved blades; one is flattened and serrated inner surface and other is pointed and smooth inner surface.

PATELLA BONE HOLDING CLAMP (FIG. 11.8)

- Speed lock mechanism.
- Three pronged or four pronged.
- Pointed tipped or ball tipped are also common.

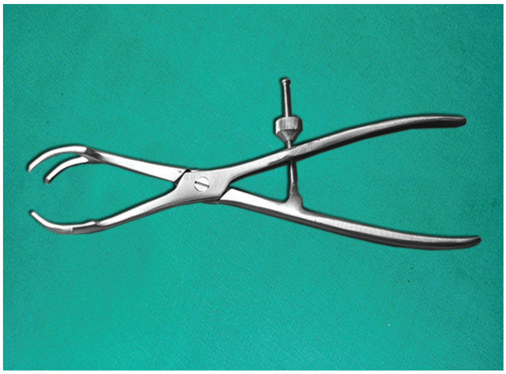


Fig. 11.8 Patella bone holding clamp

PERIARTICULAR REDUCTION CLAMP (FIG. 11.9)

- Speed lock mechanism.
- Large bends of blade accommodate peri-articular girth of bone.

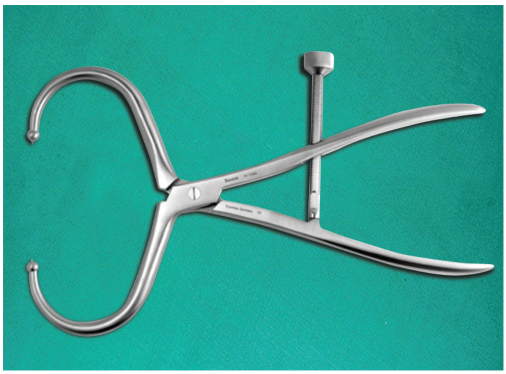
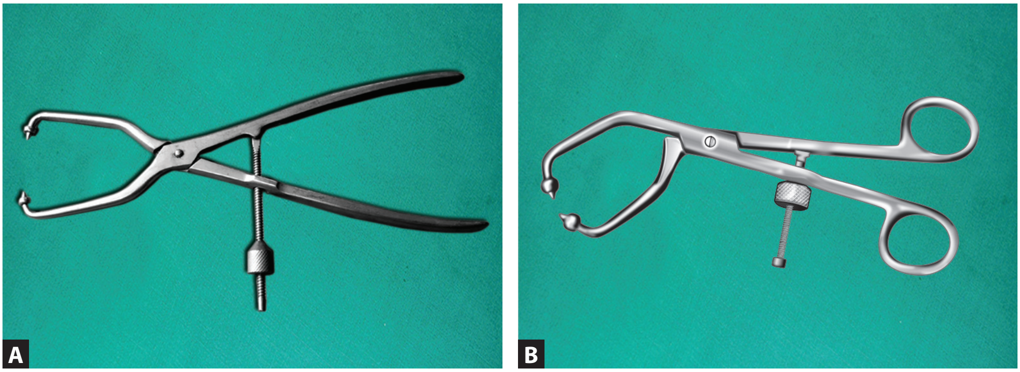


Fig. 11.9 Ball tipped (periarticular) reduction clamp

PELVIC REDUCTION CLAMP: MATTA TYPE AND DINGMAN TYPE

See Figures 11.10A and B.



Figs 11.10A and B Pelvic reduction clamp. (A) Matta type; (B) Dingman type

CHAPTER

12

Bone Piercing Instruments and Screwdrivers

BONE AWL: KUNTSCHER'S DIAMOND POINTED AWL (FIG. 12.1)

- A sharp trocar tipped instrument used for making entry point in the bone.
- Variations at piercing end
  - Straight and curved.
  - Solid or cannulated.
- *Uses:*
  - To open the medullary cavity of bone in neglected fracture or nonunion.
  - For suturing the avulsed tendon to bone, e.g. triceps to olecranon process, ligamentum patellae to patella, etc.
  - For passing of stainless steel wire through soft tissue in tension band wiring (TBW) or patellar encirclage.

BRADAWL (COBBLER'S AWL) (FIG. 12.2)

- It is just like cobbler's needle with a small hole at its arrow headed tip.

DRILL BIT (FIG. 12.3)

- It is an instrument with rounded stem with a pointed tip and two sharp cutting edges; used for making hole in bone.

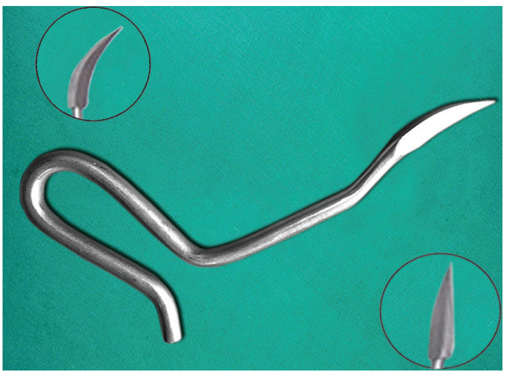


Fig. 12.1 Bone awl: Kuntscher's diamond pointed awl

Fig. 12.2 Bradawl (cobbler's awl)

- *Variations:*
  - Solid or cannulated
  - Various length and diameter.
- There is a definite relationship between drill bit diameter with cortical and cancellous screw diameter.
- Its companion instrument is manual or electric drill machine.

Fig. 12.3 Drill bit

COUNTER SINK (FIG. 12.4)

- A device that makes a conical hole in the bone so that head of screw or bolt just sit flush with or below the surrounding surface when they are tightened.
- Uses—in case of interfragmentary screw; it helps in even fitting of plate over bone surface.
- Now drill bit with counter sink are also available.

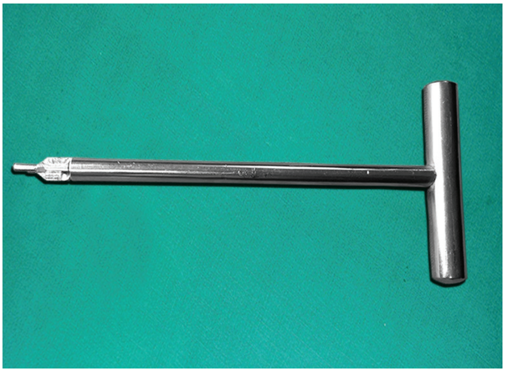


Fig. 12.4 Counter sink

BONE TAP (FIG. 12.5)

- An instrument that makes a channel in predrilled bone hole for proper fitting of screw.
- The tap diameter is same as desired screw diameter.
- Tapping is needed only for cortical screw with simple tip.

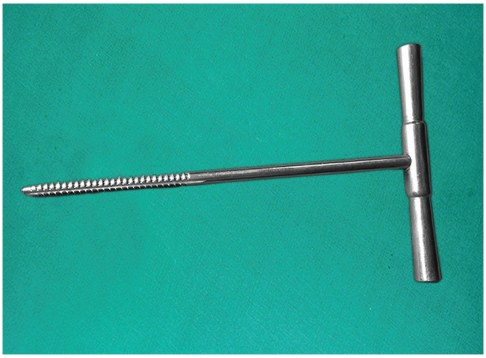
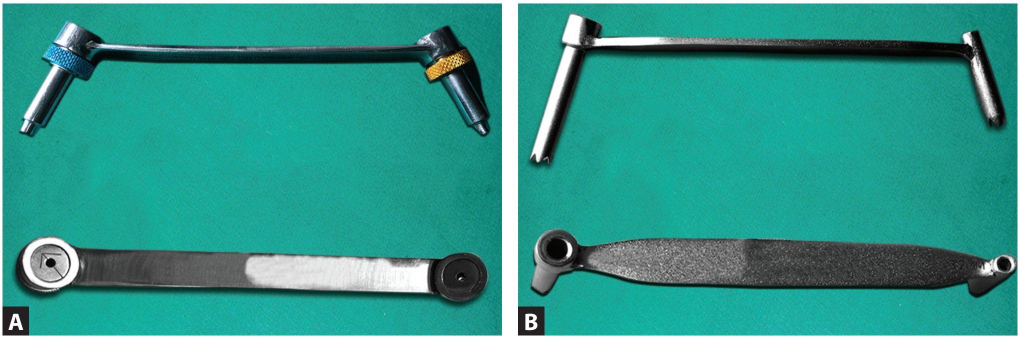


Fig. 12.5 Bone tap

DRILL GUIDE/SLEEVE (FIGS 12.6A AND B)

- A device that ensures the consistent and straight drilling of bone.
- It prevents wobbling and slippage of drill bit thus protects the fingers and keep screw in place.
- It also minimizes the use of retractors for adjacent soft tissue.
- *Drill sleeve for locking screw* are designed in such a way that they can be tightened in threads of locking plate.
- *Tap sleeve* furnishes the same purpose as drill sleeve.



Figs 12.6A and B Drill guide/sleeve

INTRAMEDULLAR REAMERS (FIG. 12.7)

- An instrument that prepare a track in medullary cavity for easy passage of implant like intramedullary (IM) nail, etc.
- *Variations:*
  - Flexible or rigid.
  - Solid or cannulated.
- *Sizes and diameters:*
  - For femur and tibia—7–13 mm; variation at interval of 0.5 mm (flexible) or 1 mm (rigid)
  - For humerus—4–9 mm; variation at interval of 0.5 mm (flexible) or 1 mm (rigid)
  - For radius and ulna—1–4 mm; variation at interval of 0.5 mm.

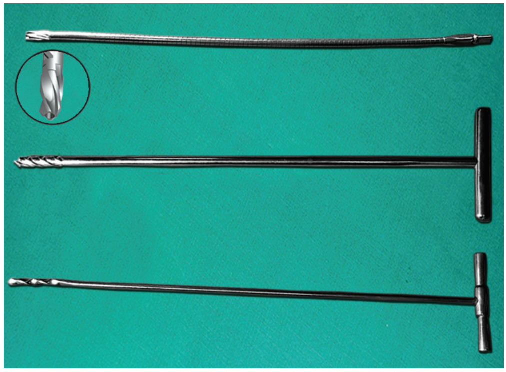
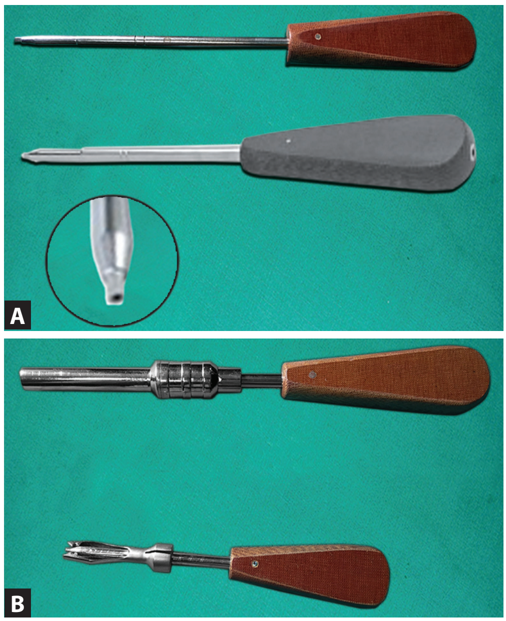


Fig. 12.7 Intramedullar reamers

SCREWDRIVERS (FIGS 12.8A AND B)

- A device that engages the screw in predrilled hole in bone.
- Its design depends upon head of screw like hexagonal, stellate, square, etc.
- *Variation:* Cannulated or solid.
- **Torque limiting screwdrivers** are used in tightening of locking screw; where a special sound from screwdriver is heard when head of screw fully engaged in plate.
- **Screw driver with screw holder**—sometimes screwdrivers are equipped with screw holder; to prevent the slippage of screw in the muscle mass as in mid-thigh.



Figs 12.8A and B Screwdrivers

CHAPTER

13

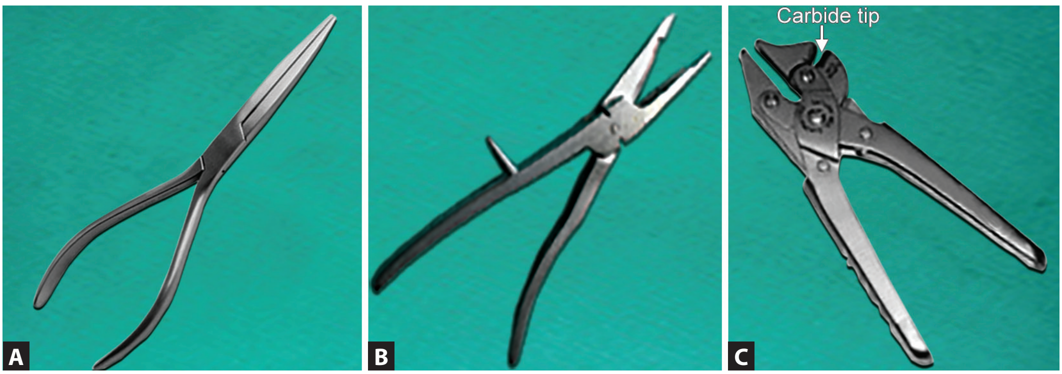
SS-wire and K-wire Handling Instruments

ORTHOPEDIC PLIERS (FIGS 13.1A TO C)

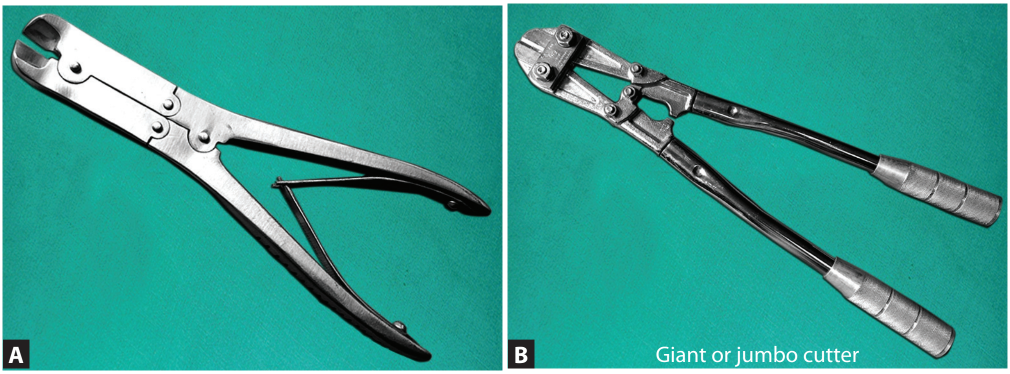
- Plier is a gripping tool having a pair of hinged arm with serrated jaw.
- It is used for holding, bending and cutting purposes.
- Some pliers (flat nose plier) are provided with small hole near the tip of its jaw that can be used as tensionier.
- *Orthopedic pliers are mainly three types:*
  1. Needle nose plier.
  2. Flat nose plier.
  3. English (parallel) plier.

WIRE AND PIN CUTTER (FIGS 13.2A AND B)

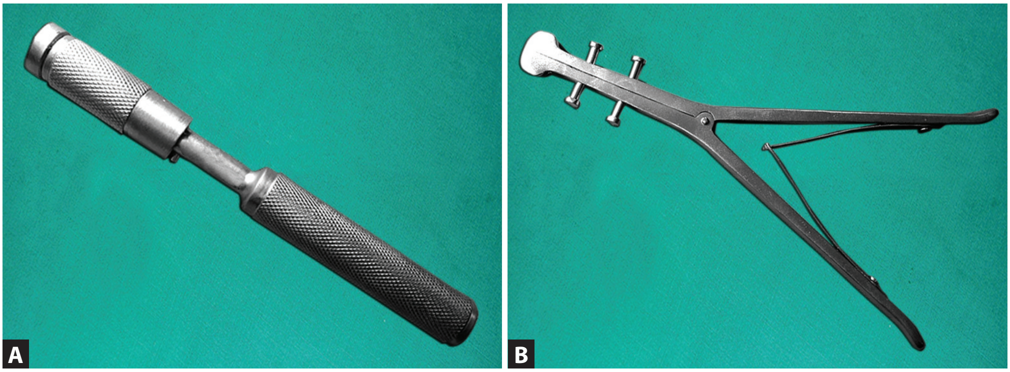
- This instrument has a pair of small stout blades with sharp edges and two handle with spring action.
- Tungsten carbide inserts are applied to increase its cutting efficiency that provides a flush cut without pinched ends.
- The cutter of longer handles to improve the lever arm mechanism having heavy duty are called giant or jumbo cutter.



Figs 13.1A to C Orthopedic pliers (A) Needle nose plier; (B) Flat nose plier; (C) English (parallel) plier



Figs 13.2A and B Wire and pin cutter



Figs 13.3A and B SS-wire tensionier

SS-WIRE TENSIONIER (FIGS 13.3 AND B)

- These tools are designed to tightened the stainless steel (SS) wires in various places like:
  - Tension band wiring
  - To keep a butterfly in reduced position
  - To hold the plate along with bone in periprosthetic fractures.

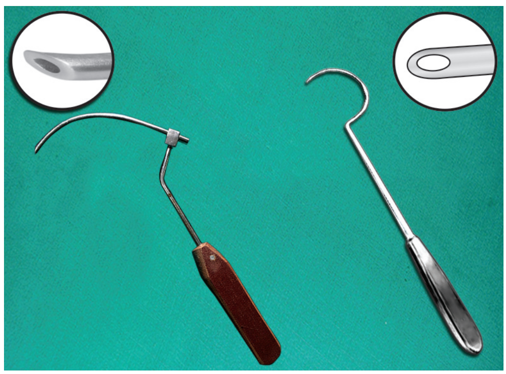


Fig. 13.4 SS-wire sleeve (wire-passer)

SS-WIRE SLEEVE (WIRE-PASSER) (FIG. 13.4)

- Two varieties are common:
  1. Tubular.
  2. Solid with an eye at its tip.
- Used to pass SS wire across the bone.

K-WIRE BENDER (FIG. 13.5)

- *Two common varieties are:*
  - Straight
  - Z-shaped
- It is a cannulated instrument used for bending the Kirschner wire (K-wire) before cutting it.

☑ *Note:* Unbended K-wire can migrate in or out of the bone.

K-WIRE INSERTER (FIG. 13.6)

- It a small T-shaped instrument with a attachment to hold the K-wire.
- It provides a firm and stable grip and K-wire insertion becomes easier.
- It can also use to hold end of guidewires.

Fig. 13.5 K-wire bender

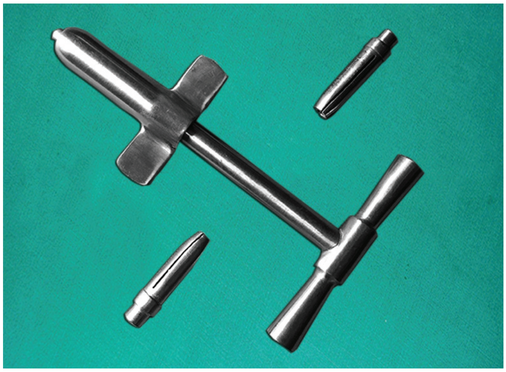


Fig. 13.6 K-wire inserter

CHAPTER

14 Miscellaneous Orthopedic Instruments

MALLET (FIG. 14.1)

- It is a orthopedic hammer with handle and cylindrical head.
- *Uses:*
  - It is a companion instrument of osteotome, chisel, gouge, etc.
  - Used for insertion of some implants such as nails (K-nail, V-nail and Rush nail), plate (wein-wright plate), prosthesis (Austin Moore), Steinmann pins, thick K-wires, etc.

ORTHOPEDIC DRILL MACHINE (FIGS 14.2A TO D)

- *Types of orthopedic drill:*
  - Hand drill with Jacob's Chuck and key—manually powered
    - Closed gear
    - Open gear
  - Power drill—powered by battery or electricity
  - Pneumatic drill—powered by gas such as nitrogen
- *Attachments for motorized drill machine and optimum rotation per minute (RPM):*
  - *Reamers:* 250–500 rpm
  - *K-wire:* 600 rpm
  - *Bone drill:* 600–1000 rpm
  - *Saw:* 1200 rpm.

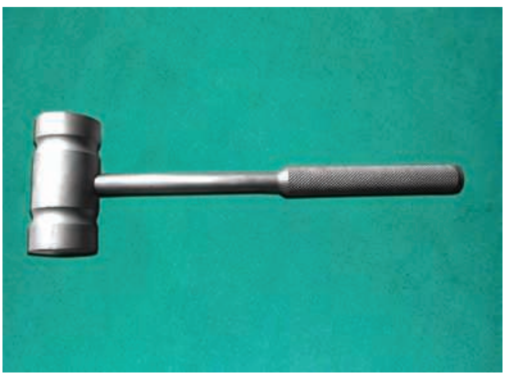


Fig. 14.1 Mallet

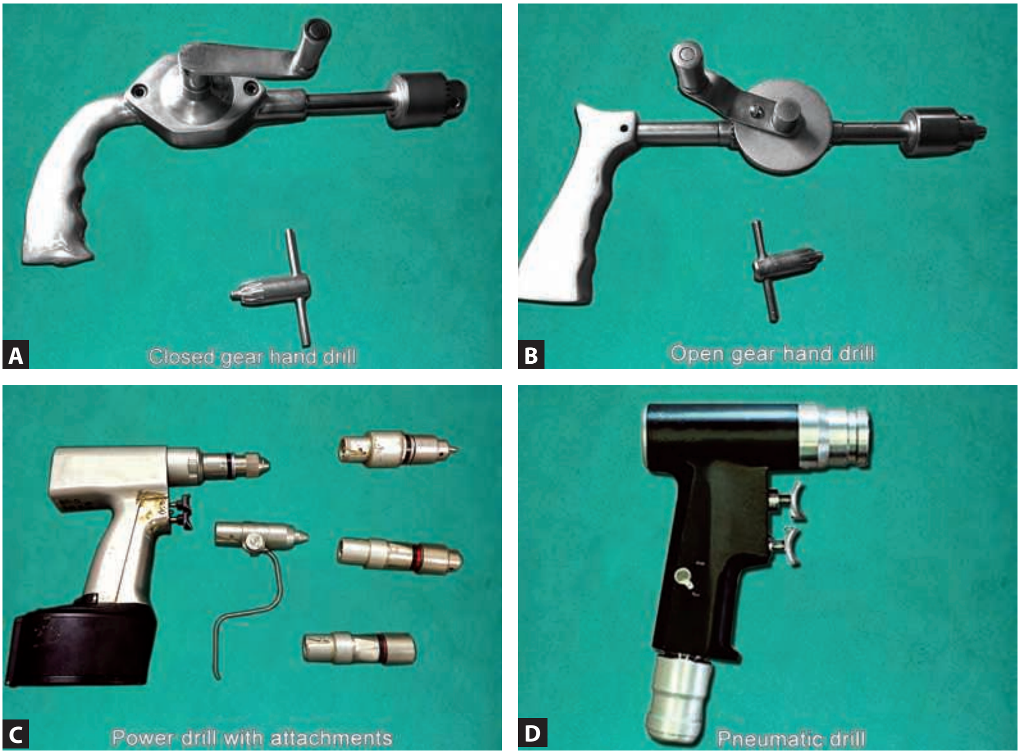
T-HANDLE WITH JACOB'S CHUCK AND KEY (FIG. 14.3)

It is T shaped instrument with Jacob's chuck at its end used for:

- Insertion and removal of Steinmann pin (skeletal traction).
- Insertion and removal of Schanz screw. (external fixator).

DEPTH-GAUGE (FIG. 14.4)

- It is a direct measuring tool with hooked tip that abuts in opposite cortex and helps in selection of perfect screw size.
- It is immediately used after drilling the bone not after tapping because hook of depth gauge may harm the channel made by tapping.



Figs 14.2A to D Orthopedic drill machine

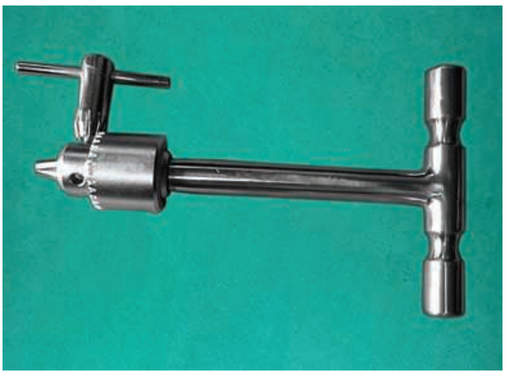


Fig. 14.3 T-handle with Jacob's Chuck and key

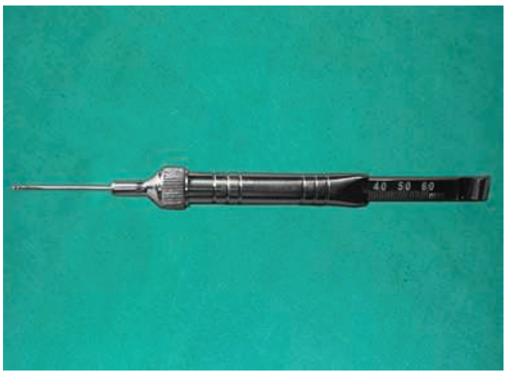


Fig. 14.4 Depth-gauge

BONE (KOCHER'S) HOOK (FIG. 14.5)

It is J shaped hooked instrument with sharp or blunt tip, used for:

- Lifting of sagging bone fragment.
- Gentle pulling of fracture fragment buried in adjacent soft tissue.

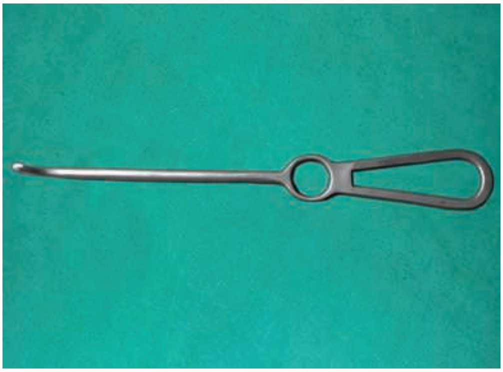


Fig. 14.5 Bone (Kocher's) hook

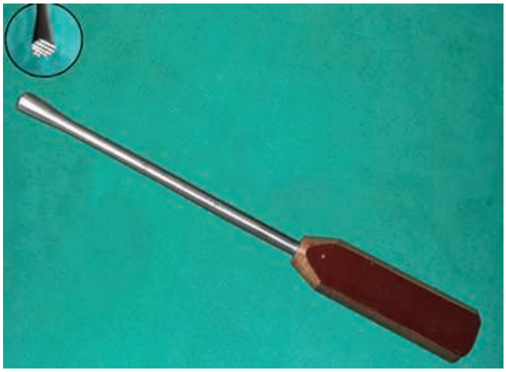


Fig. 14.6 Bone graft impactor

BONE GRAFT IMPACTOR (FIG. 14.6)

- It features a stem with variable length ending with a mesh like serrated heads of various shape.
- Useful for perfect setting of bone graft.

BONE FILLER (FIG. 14.7)

- It features a mesh like serrations on its body.
- Useful for reshaping of uneven or jagged edges of bone that may harm the adjacent soft tissue.

Fig. 14.7 Bone filler

HOLLOW MILL (FIG. 14.8)

- It is one end is equipped with saw tooth cutting edges and other end is fitted with a handle.
- It bores a clean hole in the bone thus help in easy removal of broken or headless screw buried in the bone.

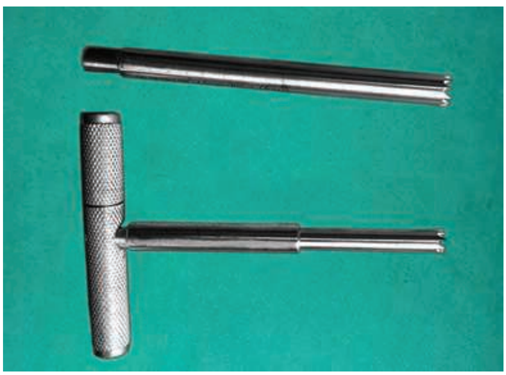


Fig. 14.8 Hollow mill

WRENCH OR SPANNER (FIG. 14.9)

- It is a tool with long handle for taking advantages of torque with jaws and hole at its two ends.
- *Types of spanner:*
  - Open end type
  - Box end type
  - Combination of open and box type

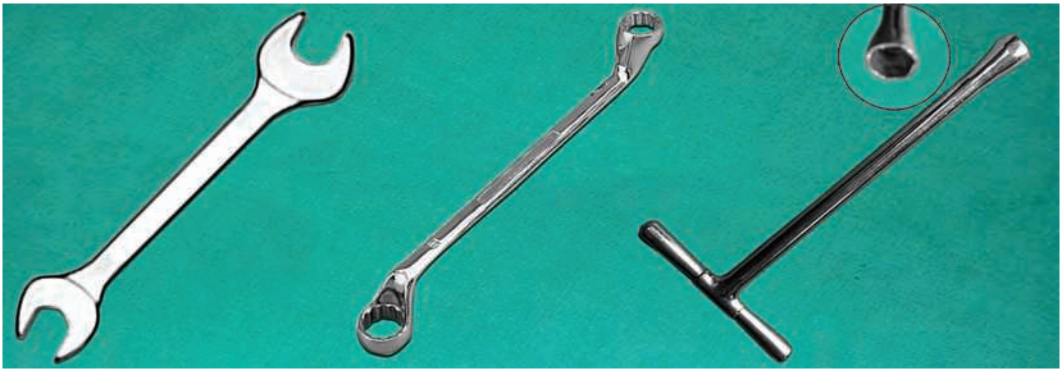


Fig. 14.9 Wrench or Spanner

- Used for tightening or loosening the various types of nuts and bolts used in external fixators.

DYNAMOMETER (FIG. 14.10)

- It is a device to produce load (50–130 kg) for tensioning the Ilizarov wire.
- Used to tensioned the Ilizarov wire during application of ring fixator otherwise they can bend.

Fig. 14.10 Dynamometer

ALLEN KEY (FIG. 14.11)

- It is a L shaped wrench which is hexagonal in cross section.
- Used as a driver for bolt and screw with head having hexagonal socket.

FEMORAL DISTRACTOR AND DISTAL RADIAL DISTRACTOR (FIGS 14.12A AND B)

- It is an assembly of equipment such as Schanz screw, clamps, sliding rod, etc.
- *Uses:*
  - For open or closed reduction of fractures by guided motion around fracture. The universal fixator is removed after definitive implantation.
  - Also used for distraction histogenesis.
- Radial distractor is used in radiocarpal fracture dislocation.

Fig. 14.11 Allen key

Fig. 14.12A Femoral distractor

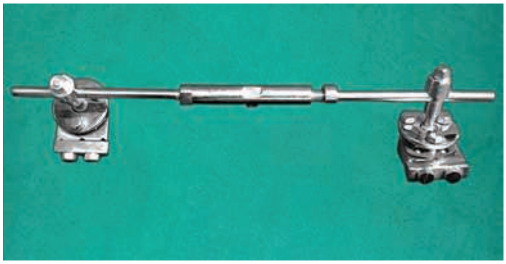


Fig. 14.12B Distal radial distractor

SEQUESTRUM FORCEPS (FIG. 14.13)

- It has smaller blades with serrated and fenestrated inner surfaces.
- No locking mechanism in handle.
- Used for holding the sequestrum; a necrotic piece of bone. Its serrated blades holds the specimen firmly and catchless mechanism prevents the crushing of material.

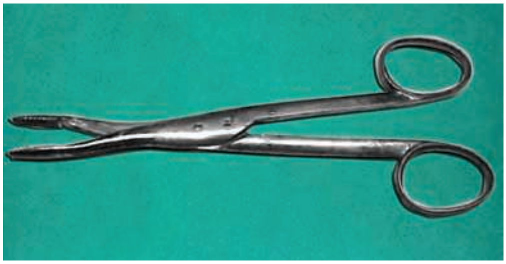


Fig. 14.13 Sequestrum forceps

CARTILAGE (MARTIN'S) HOLDING FORCEP (FIG. 14.14)

- It has small toothed blades in jig-saw manner.
- Equipped with catch lock mechanism.
- Used for holding tough cartilaginous structure such as meniscus, labrum, etc.

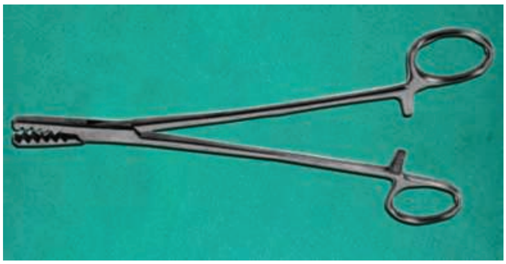


Fig. 14.14 Cartilage (Martin's) holding forcep

TENDON STRIPPER (FIG. 14.15)

- A long stemmed instrument with a tubular end with fairly sharp edges.
- *Two types:* Closed and open type
- Used for tendon harvesting for procedure such as ligament reconstruction around joint, e.g. anterior cruciate ligament (ACL) reconstruction

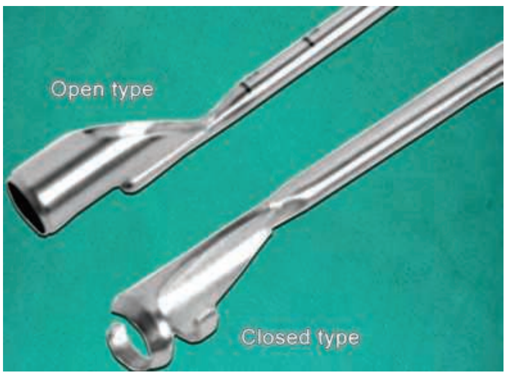


Fig. 14.15 Tendon stripper

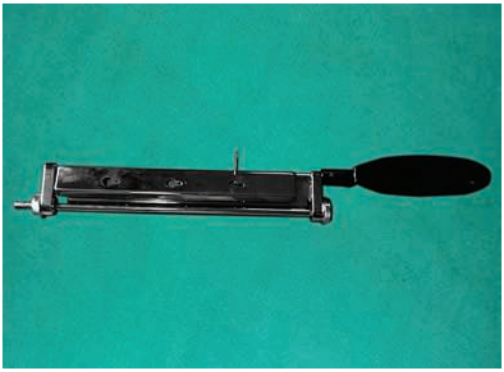


Fig. 14.16 Humby's knife

HUMBY'S KNIFE (FIG. 14.16)

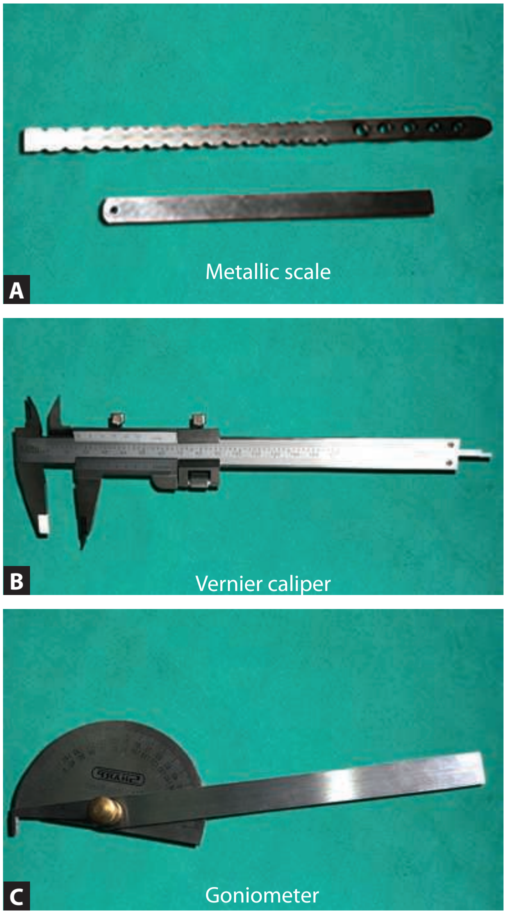
- *Parts:*
  - Handle
  - Attachment for blade
  - Adjustment for graft thickness
- Use for harvesting skin graft of various thickness.

MEASURING INSTRUMENTS (FIGS 14.17A TO C)

- Metallic scale
- Vernier caliper
- Goniometer.

PLASTER CUTTING INSTRUMENTS

- *Oscillating electrical saw (Fig. 14.18):*
- *Plaster saw [1. **Engel's** 2. **Burgman's** 3. HD (heavy duty) type] (Figs 14.19A to C):*
- ***Bohler** and **Stille** plaster shear (Fig. 14.20):*
- ***Bohler** plaster bender (Fig. 14.21):*
- ***Henning** plaster cast spreader (Fig. 14.22):*



Figs 14.17A to C Measuring instruments

Fig. 14.18 Oscillating electrical saw

Figs 14.19A to C Plaster saw

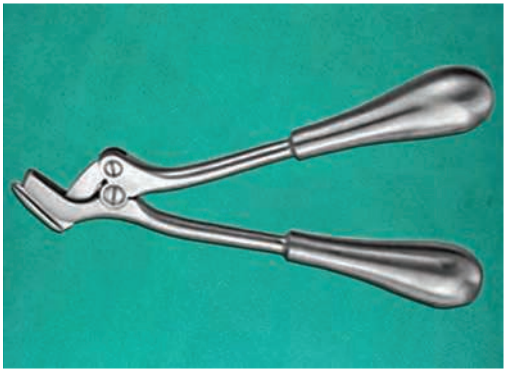


Fig. 14.20 Bohler and Stille plaster shear

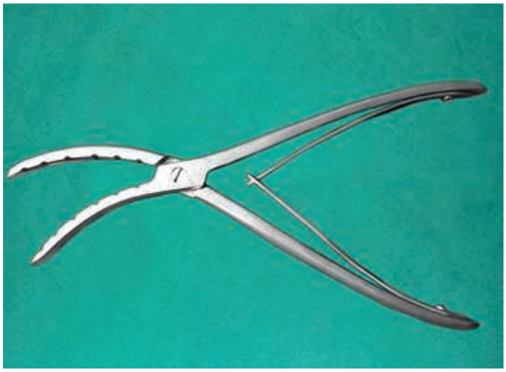


Fig. 14.21 Bohler plaster bender

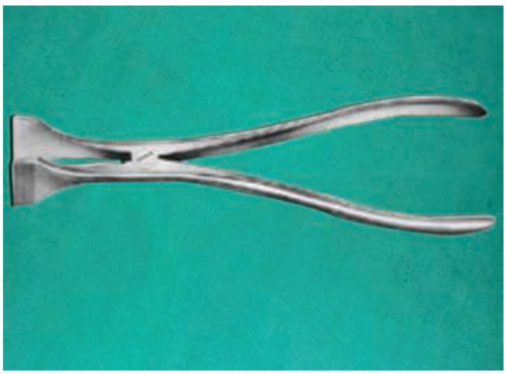


Fig. 14.22 Henning plaster cast spreader

CHAPTER

15

Special Instruments for Plating and Nailing

PLATE BENDER (FIG. 15.1)

- These tools are of various design, some can bend the plate in one plane and some in another.

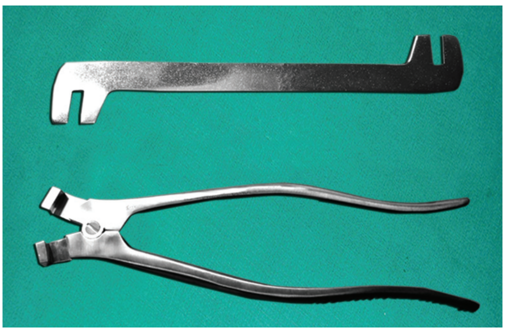
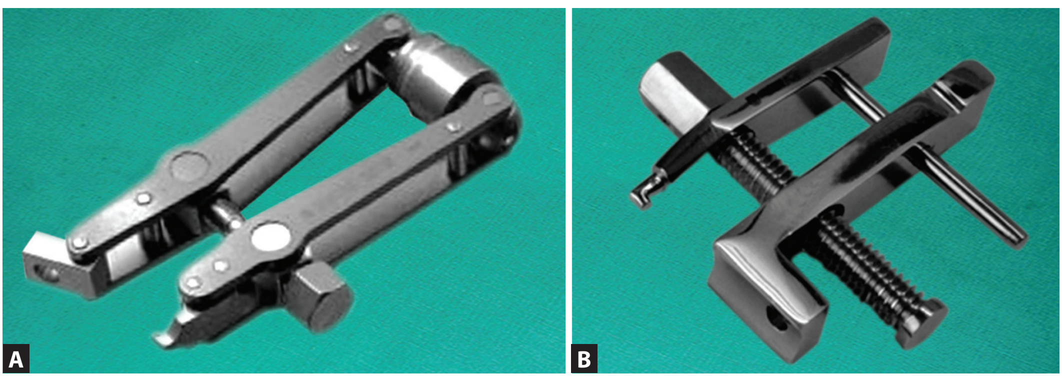


Fig. 15.1 Plate bender

- Plate should be precontoured according to its bone surface; otherwise implant would be in stress that may lead to implant failure.

MÜLLER COMPRESSION DEVICE (FIGS 15.2A AND B)

- This device has three main component:
  1. A hook system
  2. A screw system
  3. A compression unit
- How to apply this instrument:
  - One end of plate must be engaged with respective bone fragment with atleast one screw.
  - The one limb of device is fitted at another end of the plate with help of a hook in it



Figs 15.2A and B Müller compression device

and second limb of device is fixed with a screw in the bone

- As the compression screw is tightened the two limbs of device converges and producing compression at fracture site.

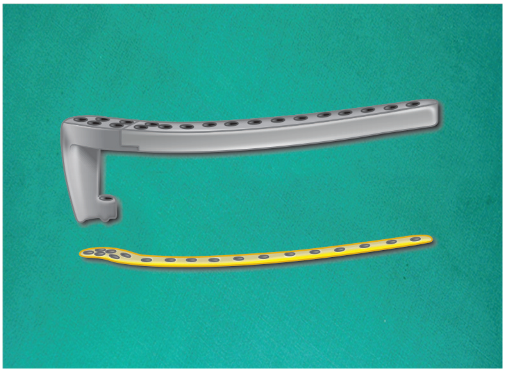


Fig. 15.3 Zig for locking plate

ZIG FOR LOCKING PLATE (FIG. 15.3)

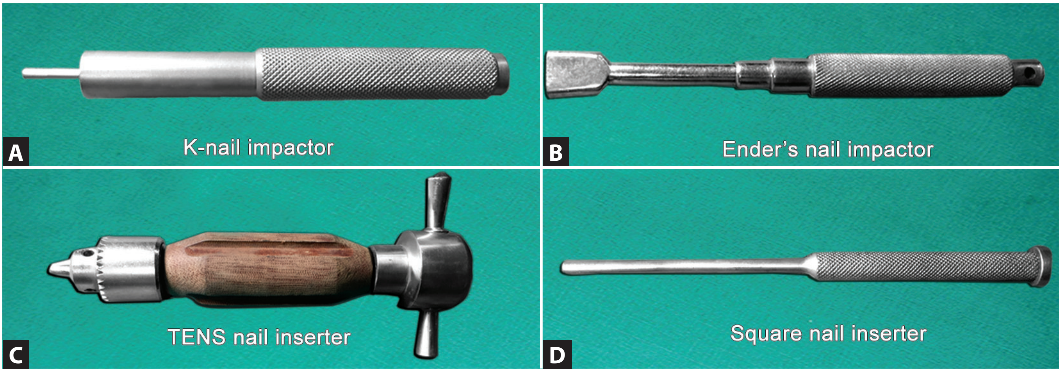
- It helps in proper localization of holes of locking plate when it is being done with minimally invasive technique.
- Once the hole of plate is localized the drill sleeve for locking screw can be tightened in these threaded holes.

INTRAMEDULLARY NAIL INTRODUCER (FIGS 15.4A TO D)

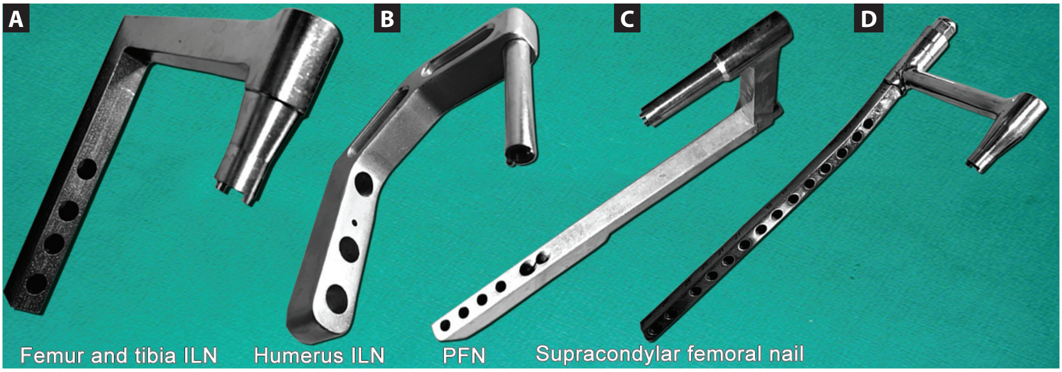
- K-nail impactor
- Ender's nail impactor
- TENS nail inserter
- Square nail inserter.

ZIGS FOR NAIL INSERTION (FIGS 15.5A TO D)

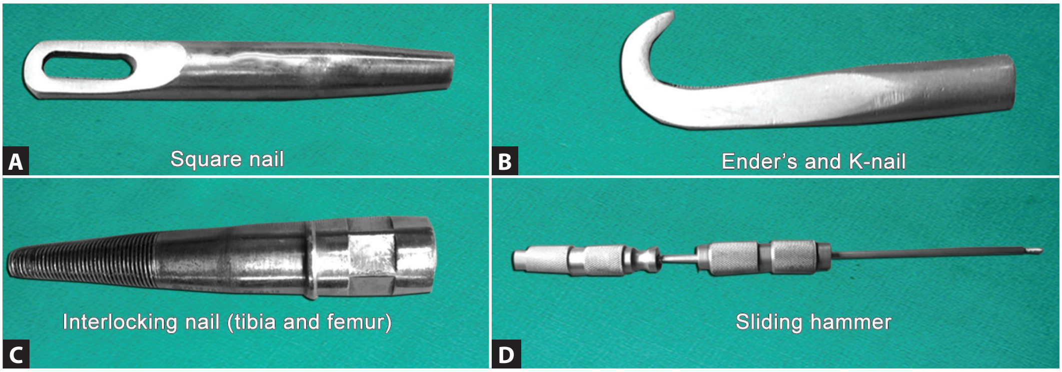
- Zigs for femur and tibia interlocking nail (ILN).



Figs 15.4A to D Intramedullary nail inserters



Figs 15.5A to D Zigs for nail insertion



Figs 15.6A to D Nail extractors

- Zigs for humerus interlocking nail.
- Zigs for proximal femoral nail (PFN).
- Zigs for supracondylar femoral interlocking nail.

NAIL EXTRACTORS (FIGS 15.6A TO D)

- For square nail extractor
- For Ender's and K-nail nail extractor
- For interlocking nail extractor
- Sliding hammer is a companion instrument for above extractors.

BROKEN NAIL EXTRACTOR (FIG. 15.7)

- It features a long stem ending with hard threaded cone that fits in the hollow of distal part of broken nail when it is rotated clockwise.

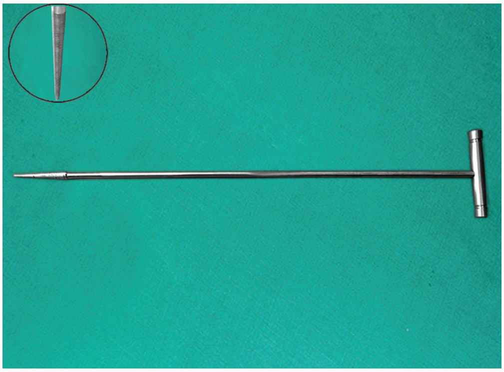


Fig. 15.7 Broken nail extractor

- Once the instrument snugly fits in broken nail; distal bolt of interlocking nail is removed and broken piece is extracted.

CHAPTER

16

Key Instruments for DHS and DCS

GUIDEWIRE (FIG. 16.1)

- Guidewire length—23 cm.
- Diameter—2.5 mm.

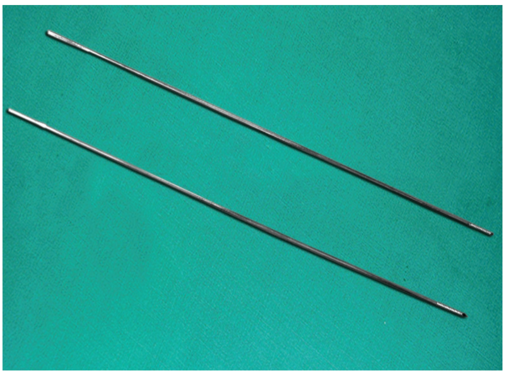


Fig. 16.1 Guidewire

ANGLE GUIDE (FIGS 16.2A TO C)

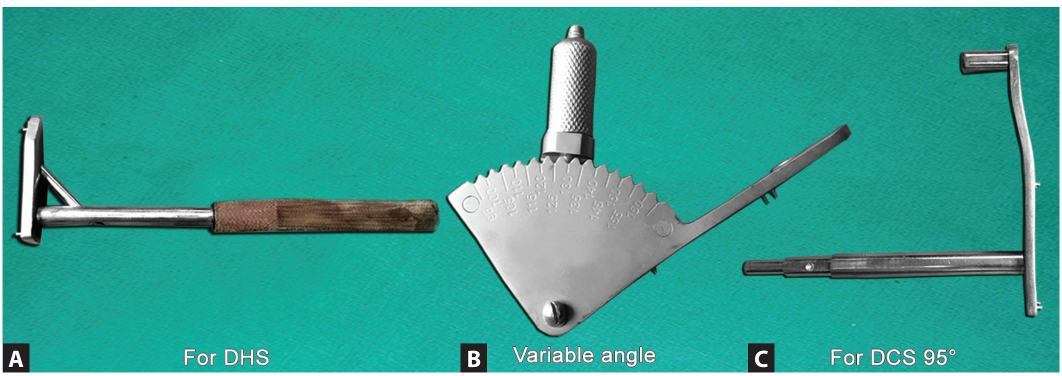
- *For dynamic hip screw (DHS):*
  - *Fixed angle:* 130° and 135°.
  - *Variable angle:* 120°–150° at interval of 5.
- *For dynamic condylar screw (DCS):* 95°

TRIPLE REAMER (FIGS 16.3A AND B)

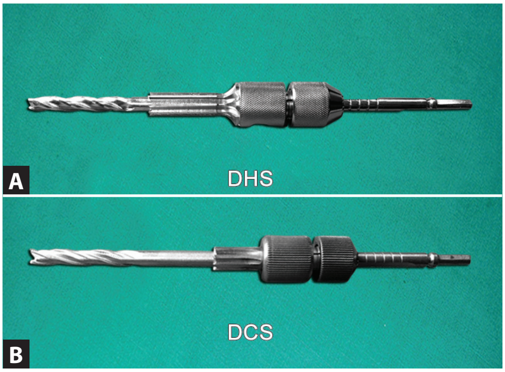
- Distal diameter (8 mm)—for screw.
- Middle diameter (12 mm)—for barrel.
- Proximal diameter (23 mm)—for shoulder (junction of barrel and plate).

DIRECT MEASURING DEVICE (FIG. 16.4)

- Calibrated in such a way that it can directly measure the length of guidewire present inside the bone.



Figs 16.2A to C Angle guide



Figs 16.3A and B Triple reamer
Abbreviations: DHS, dynamic hip screw; DCS, dynamic condylar screw

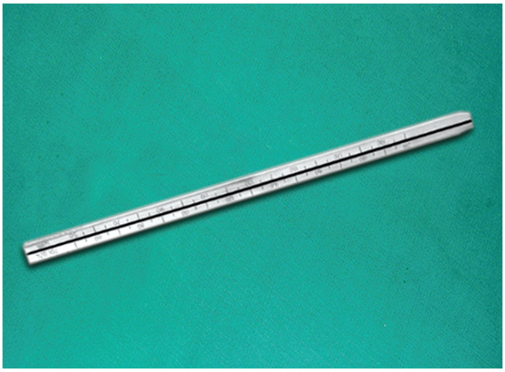


Fig. 16.4 Direct measuring device

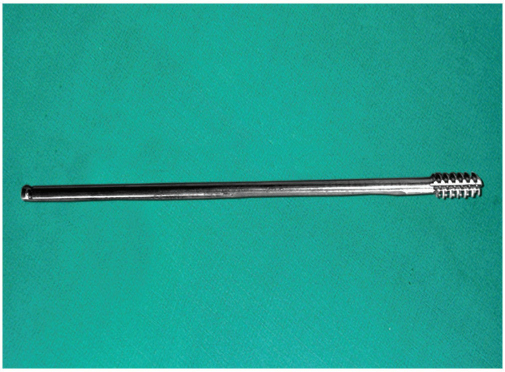


Fig. 16.5 DHS tap

Fig. 16.6 Wrench

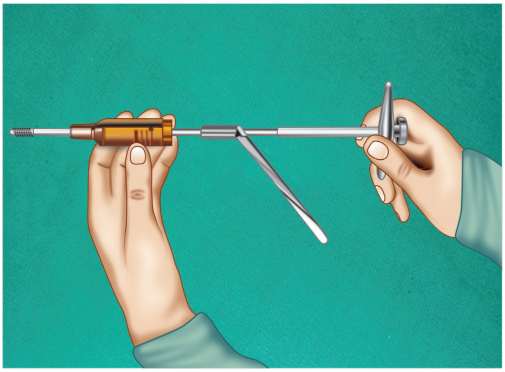


Fig. 16.7 DHS screw and plate assembly

☑ *Note*: Tapered end is the advancing end of measuring device.

DHS TAP (FIG. 16.5)

- Thread diameter—12.5 mm.
- Thread length—22 mm.

WRENCH (FIG. 16.6)

- Designed in such a way that it accommodate the shaft of DHS screw.
- Internal diameter—8.0 mm.

DHS SCREW AND PLATE ASSEMBLY

See Figure 16.7.

CHAPTER

17

Key Instruments for Spine Surgery

COBB'S ELEVATOR (FIG. 17.1)

- *Parts:*
  - Handle-stout and cylindrical.
  - Shaft.
  - Paddle-flattened and semisharp
- *Use:* For elevation of the paraspinal muscle away from the bone to allows visualization of spine.

SELF-RETAINING SPINAL RETRACTORS

Cervical Retractor (Fig. 17.2)

- *Features:*
  - Ratchet lock.
  - Joints in retractors that can adjust the blades in different plane.
  - Nonrigid blades—toothed or untoothed, variable width and depth.
- *Use:* **Cloward type** is commonly used retractor for retracting the soft tissue during surgery over cervical spine.

Posterior Spinal Retractor (Figs 17.3A and B)

- *Features:*
  - *Two locks are commonly used:*
    1. Ratchet lock
    2. *Finochietto type:* Fenestrated blades with hand-crank lever to separate the arm of retractor and lock them at each stop.

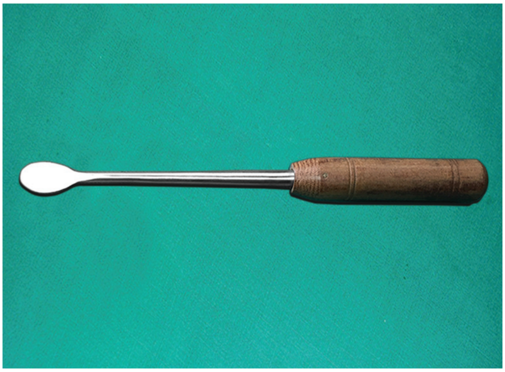


Fig. 17.1 Cobb's elevator

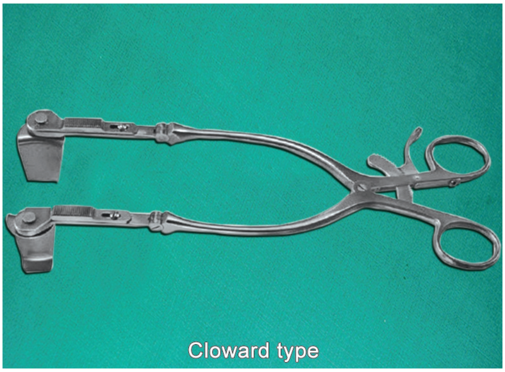
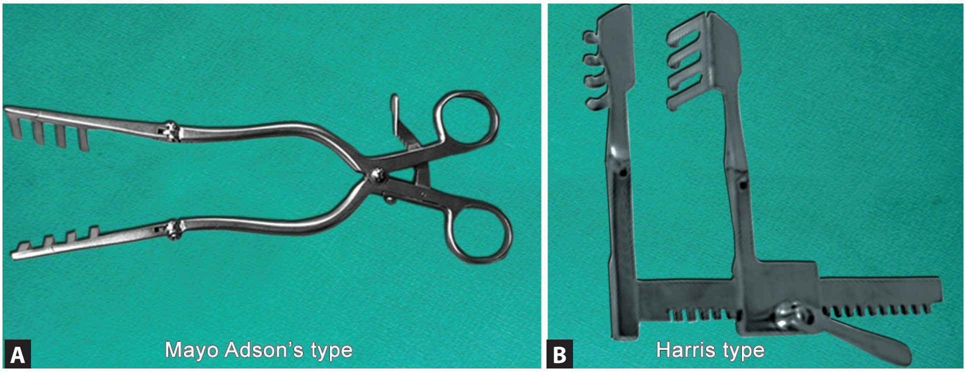


Fig. 17.2 Self-retaining spinal retractors



Figs 17.3A and B Posterior spinal retractor

- Joints in retractors that can adjust the blades in different plane.
- Blades—rigid type, pronged, removable or fixed type and of variable width and depth.

- *Used:* For retraction of paraspinal structures during surgery over spine from posterior approach, e.g. (**Mayo Adson's type and Harris type**).

RIB RETRACTOR (FIG. 17.4)

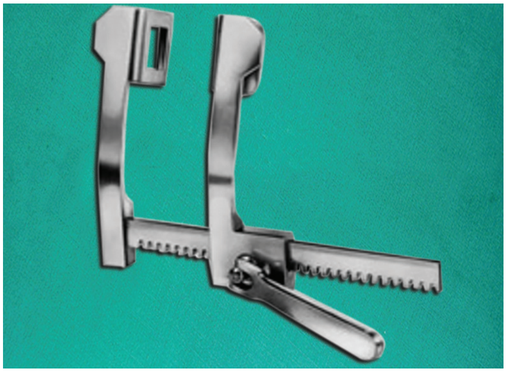


Fig. 17.4 Rib retractor

- *Features:*
  - Ratchet lock or finochietto type.
  - Smooth nontoothed and rigid blades that could not harm underlying organ.
- *Used:* For spreading of ribs during trans-thoracic surgery.

DOYEN'S RIB RASPATORY (FIG. 17.5)

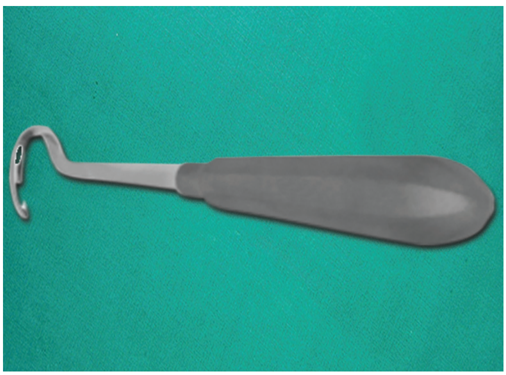


Fig. 17.5 Doyen's rib raspatory

- *Parts:*
  - Handle-ribbed for good hold.
  - Shaft.
  - Semicircular sharp blade.
- *Use:* As periosteum elevator from inner surface of rib.

RIB SHEAR (FIG. 17.6)

- *Parts:*
  - Handle with spring action and horizontal ridges to make grip firm.
  - Hinge
  - *Two blades:* Upper blade with cutting edges and lower blade with serrations and deep groove to support the rib.

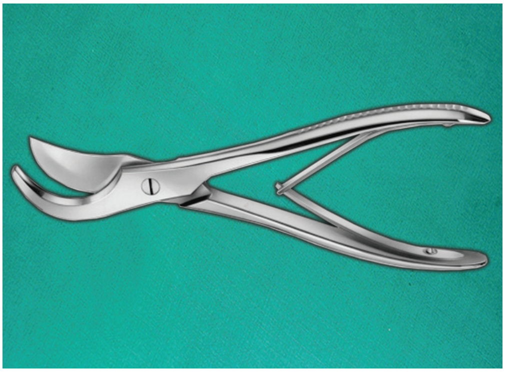


Fig. 17.6 Rib shear

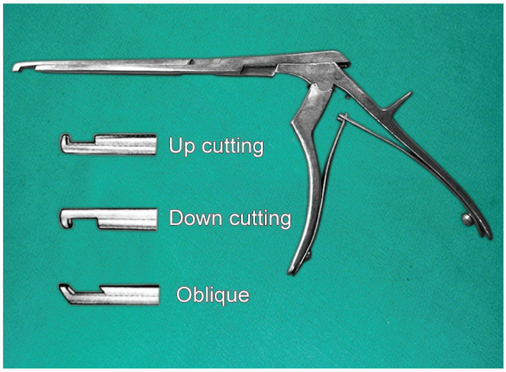


Fig. 17.7 Kerrison's Rongeurs

- *Use:* For rib resection as:
  - Anterolateral decompression and transthoracic approach in Pott's spine.
  - Benign tumor of ribs.

KERRISON'S RONGEURS (FIG. 17.7)

- *Parts:*
  - Hand piece with spring action
  - Long sliding stem
  - Jaw.
- *Variation in jaw*
  - Jaw width—1 mm, 2 mm, 3 mm, 4 mm, 5 mm
  - Jaw slant—40°/90°
  - Cutting edges—up-cutting or down-cutting.
- *Uses:* For removal of bone in smaller area of spine, like spinal canal and intervertebral foramen.

DURA AND NERVE ROOT RETRACTORS (FIGS 17.8A TO D)

- *Dura (Adson) retractor:* A blunt hooked instrument angled at 90° used for lifting, holding and retracting the dura during spinal surgery (Fig. 17.8A).
- *Dura (McDonald) dissector:* This is blunt, narrow bladed, double ended, one straight and another curved instrument. Used for separation of peridural adhesion (Fig. 17.8B).

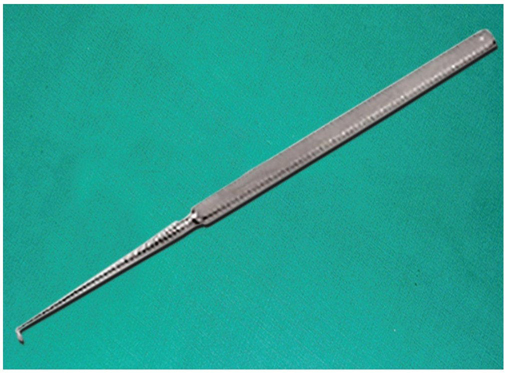


Fig. 17.8A Dura (Adson) retractor

Fig. 17.8B Dura (McDonald) dissector

- *Brueet dura elevator:* This is a double ended instrument with a blunt ended obtuse angled hook at both end (Fig. 17.8C).

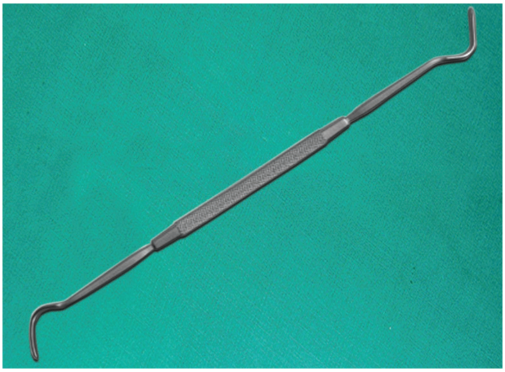


Fig. 17.8C Brueet dura elevator

- – Paired cupped jaw.
- *Variations:*
  - – Straight or angulated jaw.
  - – Different size of jaw.
- *Uses:* For removal of disc material in surgery of prolapsed intervertebral disc cases.

PEDICLE AWL (FIG. 17.10)

- It is sharp trocar like instrument with a guard near its tip.
- Used to perforate the cortex corresponding to entry point of pedicular screw.

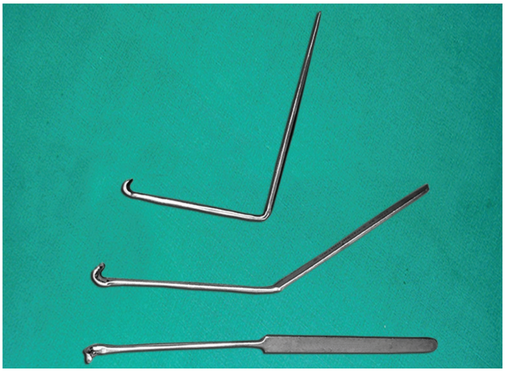


Fig. 17.8D Nerve root (Love) retractor

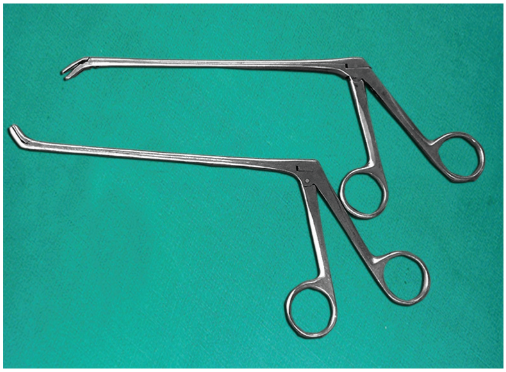


Fig. 17.9 Discectomy (Codman's) forceps

- *Nerve root (Love) retractor:* A blunt hooked instrument used for lifting, holding and retracting the nerve root during spinal surgery. These may be straight or bent (Fig. 17.8D).

☑ *Note: Penfield's* dura and nerve dealing instrument set is also commonly used.

DISCECTOMY (CODMAN'S) FORCEPS (FIG. 17.9)

- *Parts:*
  - – Pair of handle.
  - – A pair of extension arm.

Fig. 17.10 Pedicle awl

PEDICLE PROBE (FIG. 17.11)

- It is narrow, flattened and blunt tipped instrument.
- *Variations:* Straight or curved, solid or cannulated.
- Used to enhance the pedicular hole inside the vertebral body initiated by pedicle awl.
- *Caution:* Sudden plunging or bony resistance indicates either perforation or abutment in pedicular wall.

PEDICLE SOUND (FIG. 17.12)

- It is flexible ball tipped instrument.
- It is used to ensures the uniform bony resistance all around the pathway of pedicular screw even at end of the hole in vertebral body.

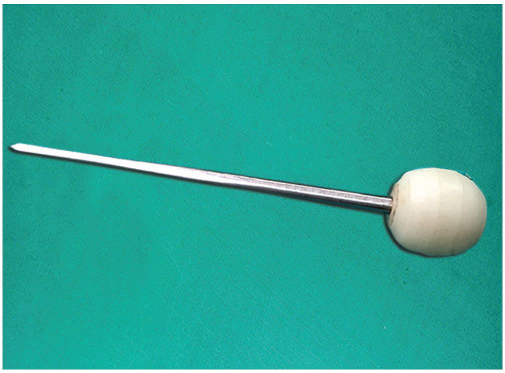


Fig. 17.11 Pedicle probe

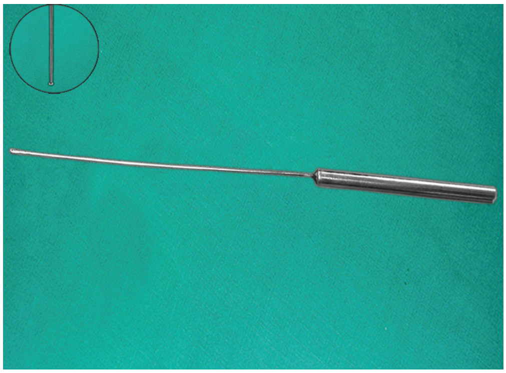


Fig. 17.12 Pedicle sound

CHAPTER

18

Key Instruments for Hip Hemiarthroplasty

CHARNLEY'S SELF-RETAINING INITIAL RETRACTOR (FIG. 18.1)

- *Components:*
  - C-frame.
  - Two curved and pronged retraction blade:
    - *Smaller blade (1.25" × 1"):* Apply posteriorly.
    - *Longer blade (3.5" × 1"):* Apply anteriorly.
  - *Weight on chain:*
- *Uses:* Used for retraction of soft tissue during surgery on hip joint; most commonly in posterior approach for hip arthroplasty.

☑ *Note: Charnley's pins (2 pins) retractor:* It is used in total hip arthroplasty, one is fixed in posterior and other is used in superior aspect of acetabulum.

CORKSCREW (JUDET) (FIG. 18.2)

- It is a T-shaped instrument with threaded cone at one end and handle at other end.
- Used for removal of femoral head from acetabulum during hip arthroplasty. It can be also used for removal of stucked interlocking nails.

☑ *Note*: Rotate clockwise or anticlockwise after inserting the corkscrew in femoral head so that ligamentum teres could be detached.

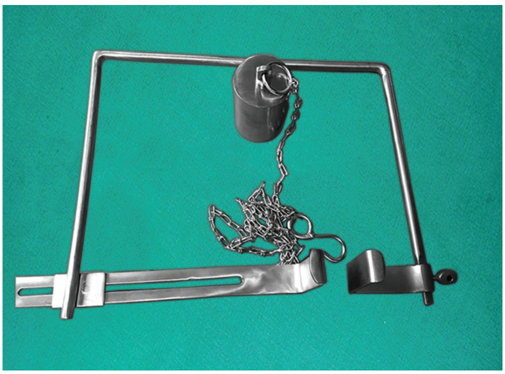


Fig. 18.1 Charnley's self-retaining initial retractor

Fig. 18.2 Corkscrew (Judet)

HEAD MEASURING GAUZE (FIG. 18.3)

- It is a set of nine flat metallic ring of inner diameter ranging from 37 to 53 mm at difference of 2 mm.
- Used for measuring the diameter of femoral head so that prosthesis with appropriate head size could be chosen.

☑ *Note:* A trial head of appropriate size should be tested in acetabulum for proper suction fitting.

BOX CHISEL (FIG. 18.4)

- *Part:*
  - Blunt flat top.
  - Shaft.
  - Box like hollow with sharp cutting edges having triangular fenestration over two opposite surfaces.
- *Use:* For making entry point of Rasp along medial aspect of greater trochanter during femoral canal preparation, e.g.—hip arthroplasty.

RASP/BROACH WITH TOMMY BAR (FIGS 18.5A TO C)

- *Parts:*
  - Flattened top.
  - *Stem with multiple hole:* Multiple holes lessen the weight of instrument and provide place for Tommy bar application.
  - Toothed stem.
- *Variations in stem:*
  - Dotted stem or serrated stem.
  - Narrow stem or wide stem.
  - Small stem or long stem.

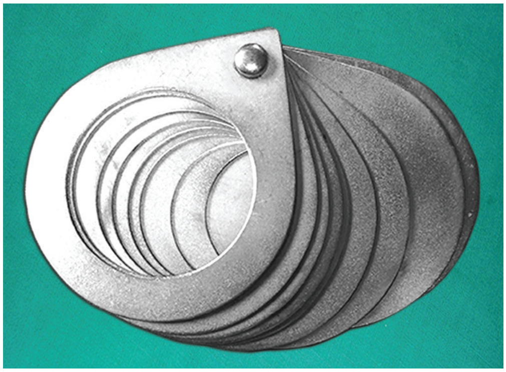


Fig. 18.3 Head measuring gauze

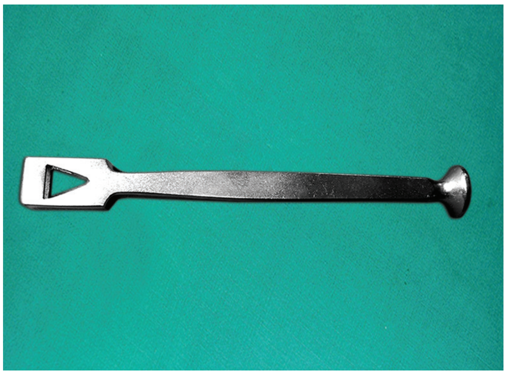


Fig. 18.4 Box chisel

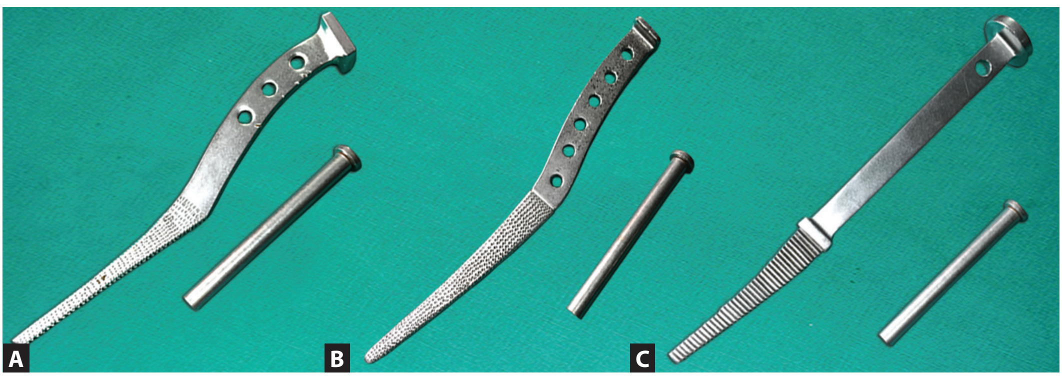


Fig. 18.5A to C Rasp/Broach with Tommy bar

- Used for femoral canal preparation for proper fitting of prosthesis stem.
- *Broaching:* It is a mechanical process to deal with cancellous and inner cortical bone of femoral canal.
- *Caution* during rasping and broaching:
  - *Care of anteversion:* Keep the knee flexed up to 90° and femur is internally rotated to such extent that long-axis of leg makes an angle of 15° with the vertical.
  - *Avoid varus positioning:* Keep the outer edge of instrument against the greater trochanter and make a direction towards medial condyle of femur.
- Tummy bar is a companion tool which is used for extraction of stucked rasp during femoral canal preparation.

MURPHY SKID (FIG. 18.6)

- It is spatula like instrument with a trough at its both end.
- It is placed against head of prosthesis for easy placement of head in acetabulum during reduction.

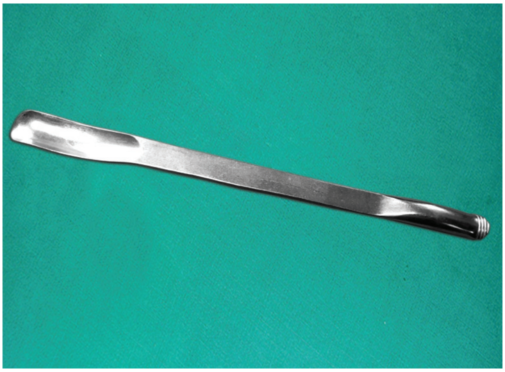


Fig. 18.6 Murphy skid

HEAD IMPACTOR (FIG. 18.7)

- It is a aluminum made light Teflon fixed impactor.
- Used for inserting the prosthesis in femoral canal without damaging the head end.

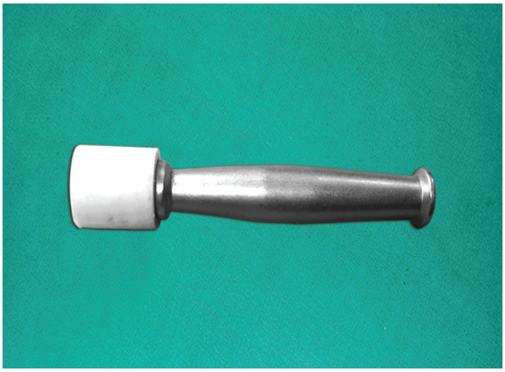


Fig. 18.7 Head impactor

CHAPTER

19

Key Instruments for Arthroscopy

ARTHROSCOPE (FIG. 19.1)

- *Optical system:*
  - Classic thin lens system.
  - Rod lens system.
  - Graded index lens.
- *Optical characteristic:*
  - Diameter—2.7 mm/4 mm.
  - Angle of inclination—30°/70° for corner.
  - *Field of vision:*
    - 90° for 2.7 mm lens.
    - 115° for 4 mm lens.

PROBE (FIG. 19.2)

- Commonly available in tip size 3–4 mm with right angled design.
- Used for exploration of joint.

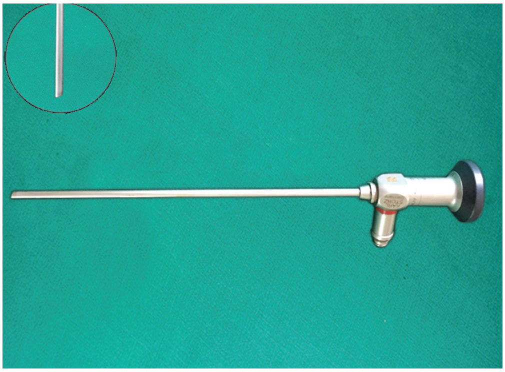


Fig. 19.1 Arthroscope

SCISSOR (FIG. 19.3)

- Commonly available in 3–4 mm diameter with straight or hooked jaw design.

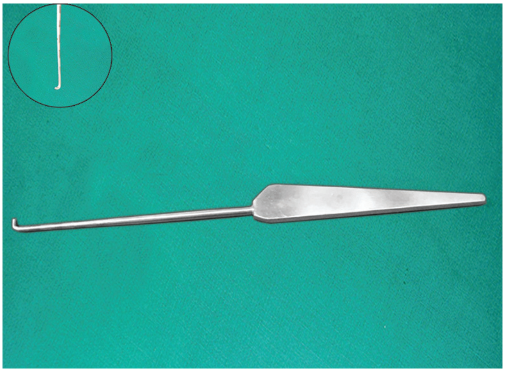


Fig. 19.2 Probe

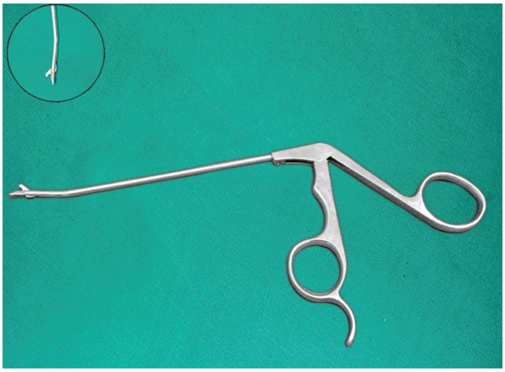


Fig. 19.3 Scissor

- Used for cutting of tissue like meniscus, labrum, etc.

BASKET FORCEPS (FIG. 19.4)

- Commonly available in 3–5 mm size with straight or hooked jaw design.
- Used for biting of tissue in very small pieces that can be easily removed by suction-irrigation system.

GRASP FORCEPS (FIG. 19.5)

Used for holding and extrusion of the free intra-articular bodies like osteochondral fragment, osteophytes, large pieces of meniscus, etc. It can also used to keep some structures under tension while cutting it with some other instruments.

ARTHROSCOPIC KNIVES (FIG. 19.6)

- Straight or curved end.
- Used for cutting of those structure where other cutting instrument cannot reach easily.

SHAVER SYSTEM (FIG. 19.7)

- The diameter of cutting tip, i.e. commonly available is 3–5.5 mm.
- The cutting tip should always lies in field of vision.
- The shaver system is activated only after window of cutting tip is positioned.

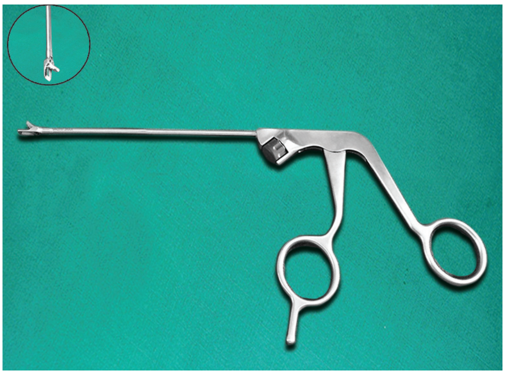


Fig. 19.4 Basket forceps

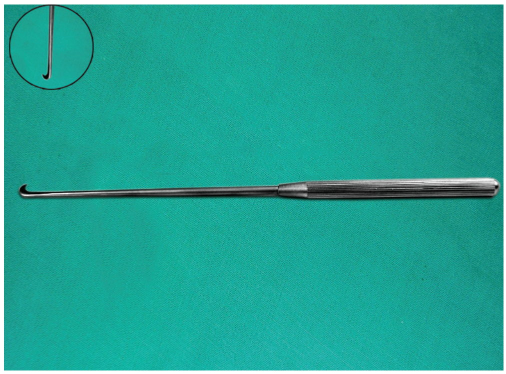


Fig. 19.6 Arthroscopic knives

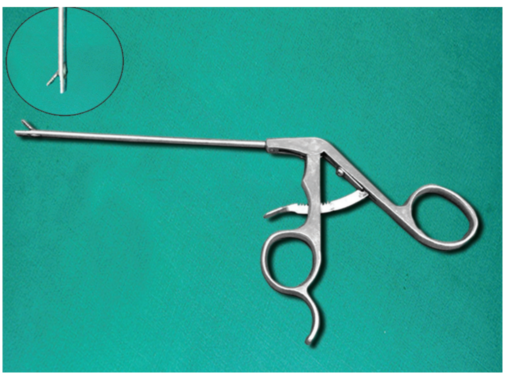


Fig. 19.5 Grasp forceps

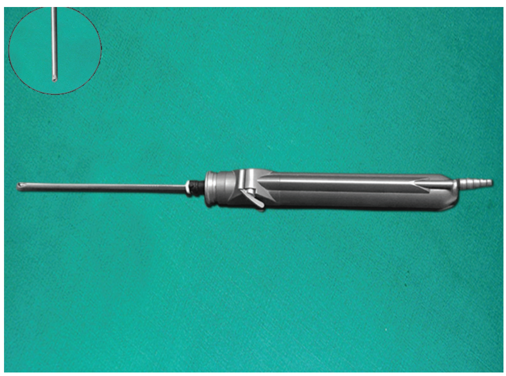


Fig. 19.7 Shaver system

CHAPTER

20

Pins, Wires and Tension Band Wiring

STEINMANN PIN (FIG. 20.1)

- *Parts:*
  - Trocar tip.
  - Smooth and rounded shaft.
  - Quadrangular top—to hold firmly in T-handle.
- *Sizes:* Diameter 3–6 mm (interval 0.5 mm), length 15–30 cm (interval 5 cm).
- *Uses:* For skeletal traction in good quality bone.

DENHAM PIN (FIG. 20.2)

- *Parts:*
  - Trocar tip.
  - Threaded (32 mm) mid-portion, thread diameter 0.5 mm more than shaft.
  - Quadrangular top—to hold firmly in T-handle.
- *Sizes:* Diameter 3–6 mm (interval 0.5 mm), length 15–30 cm (interval 5 cm).
- *Uses:* For skeletal traction in osteoporotic bone and fully cancellous bone like calcaneum.

SCREW EYE (FIG. 20.3)

- *Parts:*
  - Tip.
  - Thread.
  - Shaft.
  - Eye—to hold traction cord.
- *Size:* Diameter 4.5 mm.

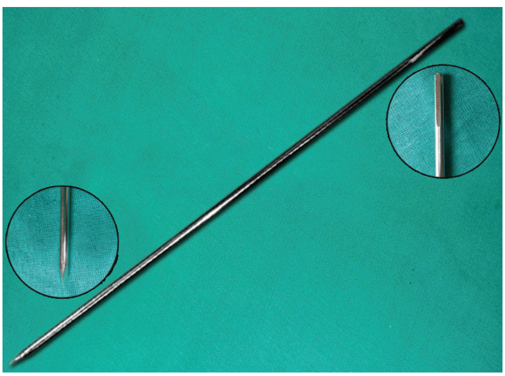


Fig. 20.1 Steinmann pin

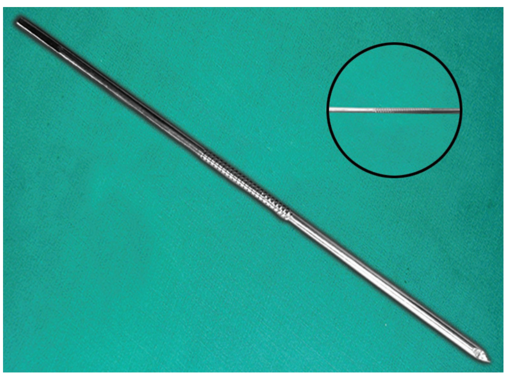


Fig. 20.2 Denham pin

- Used for upper lateral femoral traction in cases of acetabular fracture dislocation.
- Commonly combined with upper tibial traction (**Detail in Ch. 4**).

SCHANZ SCREW (FIG. 20.4)

- *Parts:*
  - Tip—make a drill hole before inserting it.
  - Thread—threaded portion engages in far cortex of bone.
  - Shaft—shaft engages in near cortex of bone.
  - Top—quadrangular top firmly holded by T-handle.
- *Sizes:* Diameter 2–6 mm (interval 0.5 mm).
  - Femur, tibia and humerus—4.5 mm, 5.0 mm, 5.5 mm.
  - Radius and ulna—3.5 mm.
  - Metacarpal and metatarsals—2.5 mm.
- *Uses:* For external fixators **(Detail in Ch. 5)**.

KIRSCHNER'S WIRE (FIG. 20.5)

- *Parts:*
  - Trocar tipped both ends.
  - Rounded shaft.
- *Variations:*
  - Smooth and threaded.
  - With stopper (compression K-wires).
- *Size:* 1–3.5 mm; at interval of 0.5 mm.
- *Uses:*
  - For pediatric skeletal traction.
  - For fixation of pediatric fracture like supracondylar fracture, physeal injury etc.
  - For fixation after correction of deformity like tibia vara, congenital vertical talus (CVT), etc.
  - As a component of Joshi's external stabilizing system (JESS).
  - As a component of tension band wiring (TBW).
  - As a temporary scaffolding for fixation of periarticular fractures.

☑ *Note:* End of K-wire protruding from skin is acutely bent and rest of the wire is cut down. Why so ?

Fig. 20.3 Screw eye

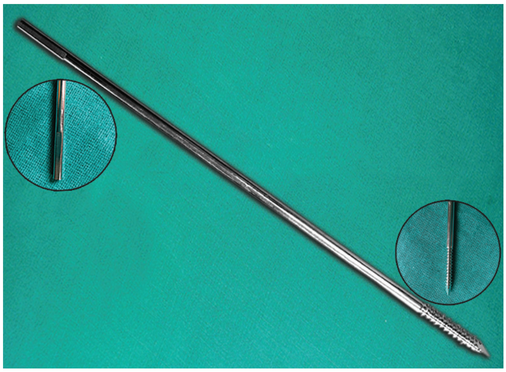


Fig. 20.4 Schanz screw

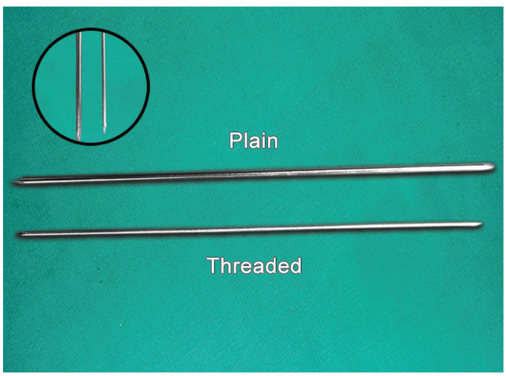


Fig. 20.5 Kirschner's wire

- It prevents inward migration of wire in the bone and soft tissue.
- It also facilitate its easy removal when purpose is solved.

STAINLESS STEEL WIRE (FIG. 20.6)

- These are stainless steel (SS) wires wrapped over wire spool.
- *Sizes:* 16 gauze (1.6 mm) to 30 gauze (0.3 mm)
- *Uses:*
  - As a component of TBW.
  - To hold the comminuted fragment where screw fixation is not possible, e.g. during intramedullary nailing in long bone.
  - To encirclage the comminuted fracture patella.
  - For reconstruction of comminuted greater trochanter.

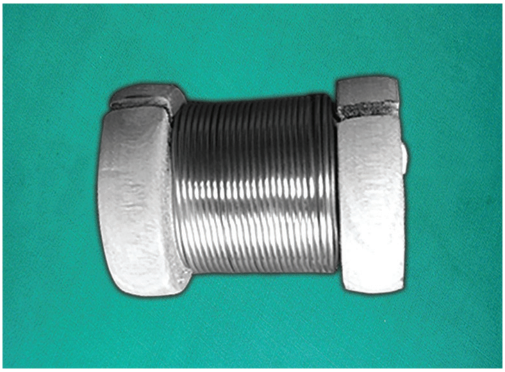


Fig. 20.6 Stainless steel wire over spool

TENSION BAND WIRING (FIG. 20.7)

- *Definition:* Method of fracture treatment where tensile forces are converted into compressive forces.
- *Principle:* Eccentrically loaded bone—tension on convex side and compression on concave side—tensile forces are absorbed by tension band wire.
- *Two types:*
  1. *Static TBW:* Tension band creates desired compression at the time of application, e.g. medial malleolar fracture.
  2. *Dynamic TBW:* Fracture fragments are subjected to additional compression when skeletal muscle comes under normal physiological load.

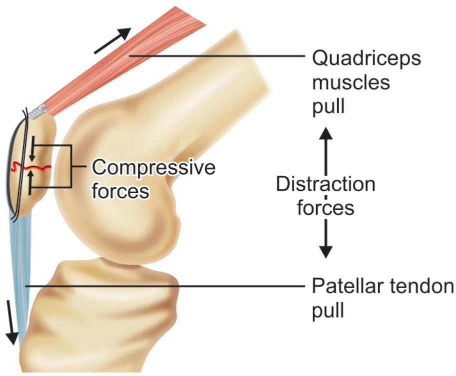


Fig. 20.7 Tension band wiring principle

- *Sites of dynamic TBW and loading muscles:*

Sites of TBW	*Loading muscles*
Fracture patella	Quadriceps and hamstrings
Fracture greater trochanter of femur	Gluteus medius and hip adductors
Fracture greater tuberosity of humerus	Supraspinatus and pectoralis major
Fracture olecranon process of ulna	Triceps and elbow flexors

CHAPTER

21

Orthopedic Screws

SCREW DESCRIPTION (FIGS 21.1A AND B)

- *Definition:* A screw is a mechanical device which converts the torsional forces into compressive force.
- *Parts of screw:*
  - *Head:* It has a recess for attachment to screwdriver. There is also a countersink for buttress which prevent sinking of head into bone. Various types of head are as follows:
    a. Single slot.
    b. Cruciate.
    c. Philips.
    d. Hexagonal.
    e. Star drive.
  - *Shaft:* It links between head and thread.
  - *Run-out:* It is a zone of transition between shaft and thread. This is a point of stress concentration. Screw may break from this site on faulty application.
  - *Thread:* It makes purchase of screw with bone.
    - Thread diameter—it represents the diameter of screw.
    - Core diameter—it is narrowest diameter and weakest part of screw.
    - Pitch—distance between two adjacent threads.
    - Purchase—resistance between screw and bone interface.

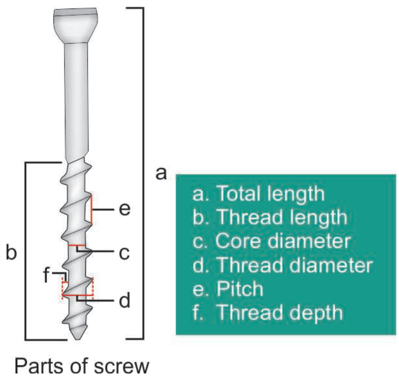


Fig. 21.1A Screw description

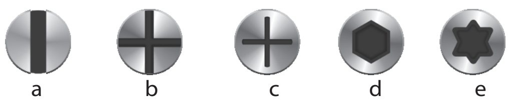


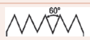
Fig. 21.1B Different types of screw head

    - Thread depth—half of difference between thread and core diameter.
    - Lead—distance traveled by screw in one turn.
  - *Tip of screw:*
    - Simple tip (nontapping)—smooth conical tip and needs tapping to make channel for passage of screw; cortical screw.
    - Self-tapping—having cutting flutes for creating a channel, e.g. locking screw.
    - Self-drilling and self-tapping—screw tip makes a drill hole and also cuts

channel for passage of screw, e.g. locking screw.
- ◆ Cork screw—e.g. cancellous screw.

- Factor affecting pull out strength of screw:
  - Number of thread engaging the cortex.
  - Type of screw; (thread depth $\propto$ pull out strength).
  - Bone quality.
  - Screw augmented with cement.
  - Hydroxyapatite Coated screw.

COMPARISON BETWEEN AO AND MACHINE SCREW

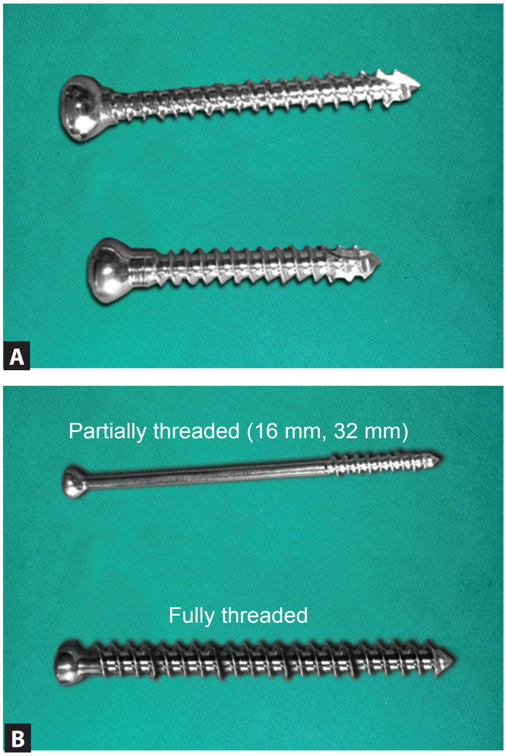
	AO screw	*Machine screw*
Number of threads	Partially or fully threaded	Fully threaded
Thread direction		
Cross-section of thread	Buttress	V shaped
Drill bit diameter	Slightly more than core diameter	Less than core diameter
Tapping nature	Nontapping or self-tapping	Self-tapping

CORTICAL AND CANCELLOUS SCREW (FIGS 21.2A AND B)

	Cortical screw	*Cancellous screw*
Modification of	Machine screw	Wood screw
Core diameter	More	Less
Thread depth	Lesser	More
Pitch	Lesser	More
Tip	Simple	Cork screw
Cutting flutes	Absent	Present
Solid or cannulated	Mainly solid	Both

LAG SCREW (FIG. 21.3)

- A screw whose threads take its purchase in far cortex and provide interfragmentary compression; called lag screw.
- *Lag screw should be:*
  - Perpendicular to fracture site.
  - Inserted in the middle of fracture line.



Figs 21.2A and B (A) Cortical; (B) Cancellous screw

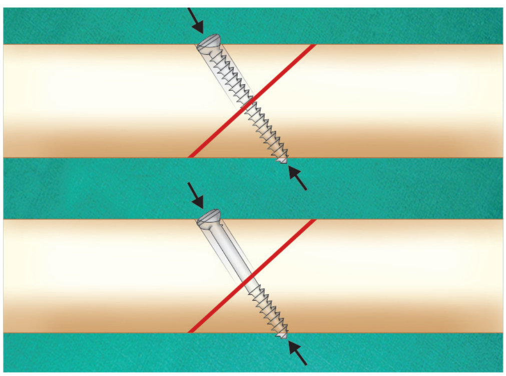


Fig. 21.3 Lag screw

- For long-oblique or spiral fracture; atleast two screws are preferred so that rotation could be prevented.
- *Drilling for lag screw:*
  - *Pilot hole in far cortex*: Normally drilled (as per screw diameter)
  - *Gliding hole in near cortex*: Over drilled (more than one size for far cortex)

☑ *Note:*
  - If partially threaded screw is used; all thread should engage in far cortex not run along the fracture site.
  - Most of the time, lag screw at fracture site are augmented with neutralization plate.

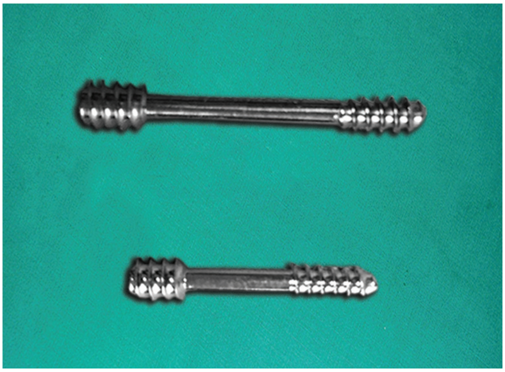


Fig. 21.4 Herbert screw

HERBERT SCREW (FIG. 21.4)

- A cannulated headless screw.
- Differential pitch between leading (3 mm) and trailing (3.9 mm) end produces lag effect.
- Provide interfragmentary compression.
- *Uses:*
  - For scaphoid fracture.
  - Capitellum fracture.
  - Radial head fracture.
  - Talus fracture.
  - Small joint arthrodesis.

Fig. 21.5 Acutrak screw

ACUTRAK SCREW (FIG. 21.5)

- A fully threaded, headless, cannulated screw.
- Differential pitch, i.e. greater pitch at tip and smaller pitch at head end causes lag effect.
- Provides interfragmentary compression.
- Can be used in place of Herbert screw,

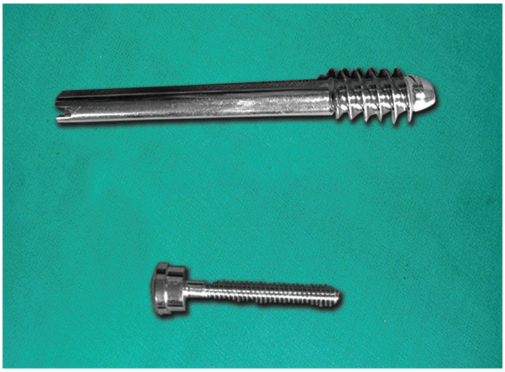


Fig. 21.6 DHS sliding screw and compression screw

DHS SLIDING SCREW (FIG. 21.6)

- A cannulated headless screw with lag effect.
- Provide interfragmentary compression.
- *Screw dimensions are as:*
  - *Screw length:* 50–130 mm
  - *Core diameter:* 8 mm
  - *Thread length:* 22 mm
  - *Thread diameter:* 12.5 mm
- Shaft is rectangular with rounded corner in transverse section that fits in similar slot of

barrel of DHS plate; it prevents the rotation of screw in barrel and finally stabilizes the fracture.

What is Richard's screw: It is ancestor of DHS sliding screw; its shaft is cylindrical with a longitudinal slot that fits in the ridge made in superior aspect of inner wall of Richard's barrel plate. Unlike DHS sliding screw; its control over rotation at fracture site is minimal.

- *DHS compression screw:*
  - It compresses the distal fragment of fracture over proximal one.
  - Length of screw—36 mm.
  - Diameter of screw—4 mm.

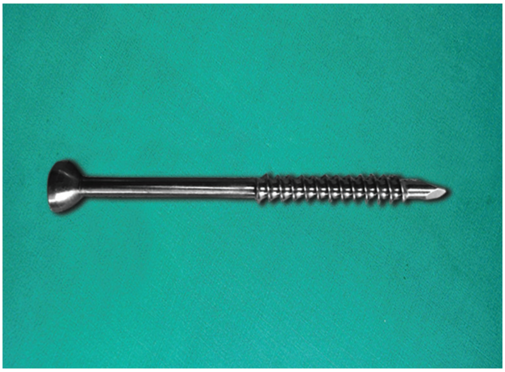


Fig. 21.7 Malleolar screw

MALLEOLAR SCREW (FIG. 21.7)

- *Malleolar screw is described as:*
  - Cortical screw.
  - Solid screw.
  - Partially threaded.
  - Trocar tipped.
  - 4.5 mm diameter.
- At present partially threaded 4 mm cancellous screw has taken its place.

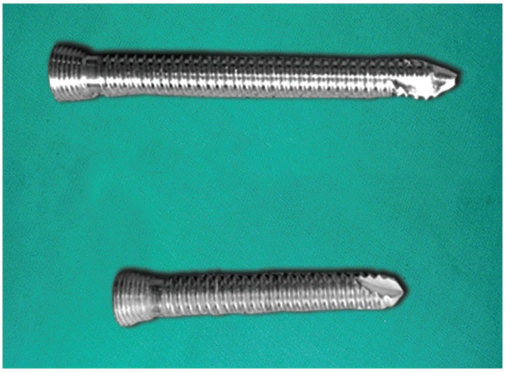


Fig. 21.8 Locking screw

LOCKING SCREW OR LOCKING HEAD SCREW (FIG. 21.8)

- *These are basically cortical screw with features like:*
  - Threaded head.
  - Can be applied only in locking plates.
- Cancellous locking screws are also being used in metaphyseal plate along with cortical screw in some designs, but their mechanics is doubtful. Why?
  - Both screw head locked in plate.
  - Both have different pitch.
  - The interaction between screw and bone interface is different in two types of bone, i.e. one cortical and another cancellous.

INTERLOCKING BOLT (FIG. 21.9)

- *Why they are called bolt-because:*
  - They are stout.
  - Having trocar tip.
  - Core diameter more.
  - Thread depth lesser.
  - Pitch more.

SOME OTHER FUNCTIONS OF SCREW

- *Anchor screw:* Act as an anchor to hold wire or suture material. For example, fixation of French osteotomy in cubitus varus deformity, TBW in proximal humerus fracture.
- *Push-pull screw:* It provides a temporary fixation for articulated compression device

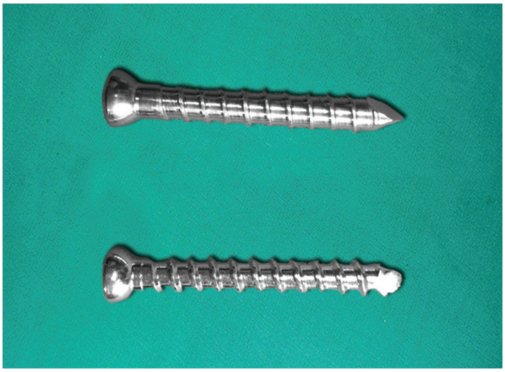


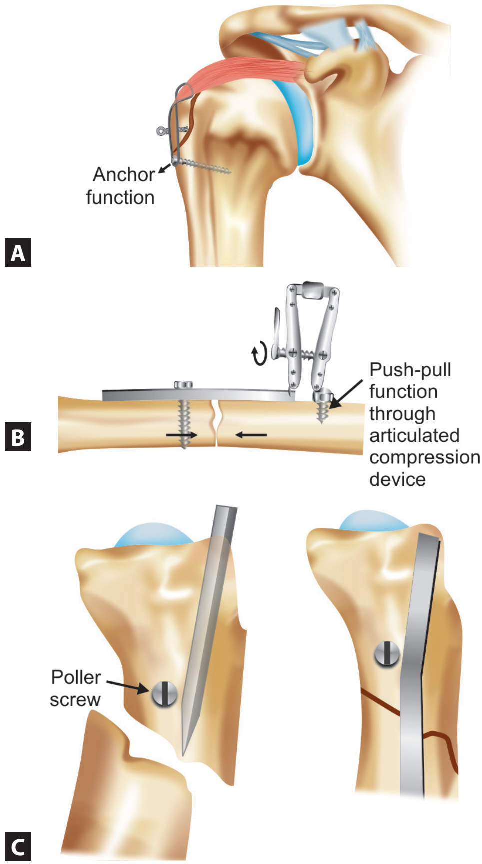
Fig. 21.9 Interlocking bolt

that reduces the fracture by compression-distraction mechanism. For example, Muller compression device.

- *Poller screw:* Used for redirection of nail during intramedullary nailing. For example, nailing in proximal tibial fracture.

VARIOUS SCREW TYPES AND DRILL BITS

Figures 21.10A to C shows various screw types and drill bits.



Figs 21.10A to C (A) Anchor screw; (B) Push-pull screw; (C) Poller screw

Screw diameter and drill bit correlation		
Screw types	*Screw diameter in mm*	*Drill bit diameter (Core diameter of screw) in mm*
Cortical screws	4.5 3.5 2.7 2.0 1.5	3.2 2.5, 2.7 2.0 1.5 1.1
Cancellous screw	6.6 4.0	3.2 2.5
Malleolar screw	4.5	3.2
Locking bolt	4.9 3.9 (for 8 mm diameter or lesser diameter)	4.0 3.0
Locking screw	5.0 4.0	4.3 3.2

CHAPTER

22

Orthopedic Plating

BONE PLATE

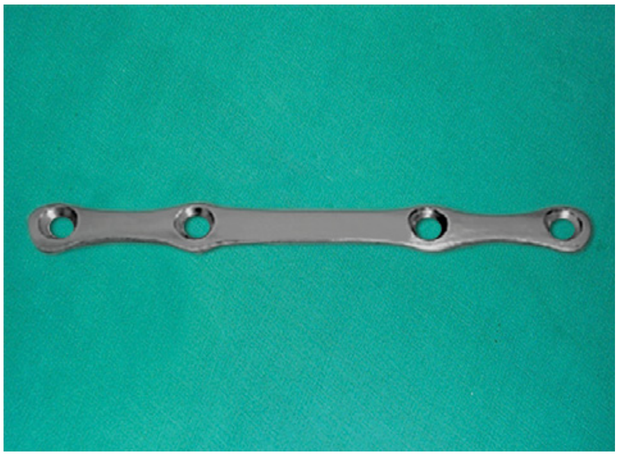


Fig. 22.1 Sherman plate (historical plate)

- Sherman plate is supposed to the first scientific plate in the history of orthopedic hardware (Fig. 22.1).
- *Definition:* A flat internal splints with holes that hold together the fracture end of bone.
- What does a plate do?
  - Maintain alignment of bone.
  - Transfer forces from one end of bone to other end.
- *Functional classification of plating:*
  - *Bridging mode (Fig. 22.2A)*:
    - *Function:* It steadies fracture fragments along with main fragments.
    - *Implant:* DCP, LCP
    - *Plate application:* Plate is applied across the fracture site.
    - *Used:* For comminuted fractures.
  - *Neutralization mode (Fig. 22.2B)*:
    - *Function:* It holds the two fracture fragments which are already fixed with inter-fragmentary screws.
    - *Implant:* Dynamic compression plate (DCP), locking compression plate (LCP)
    - *Plate application:* Plate is applied across the fracture site.
    - *Used:* For oblique fractures.
  - *Buttress mode (Fig. 22.2C)*:
    - *Function:* It strengthen the weakened area of cortex and prevents bone from

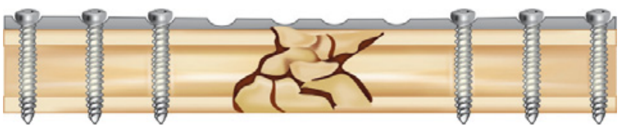


Fig. 22.2A Bridging mode of plating

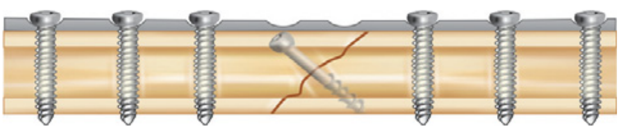


Fig. 22.2B Neutralization mode of plating

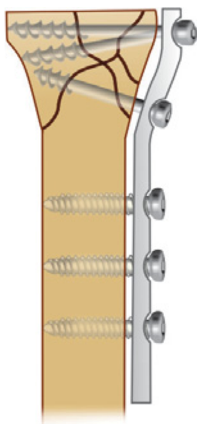


Fig. 22.2C Buttress mode of plating

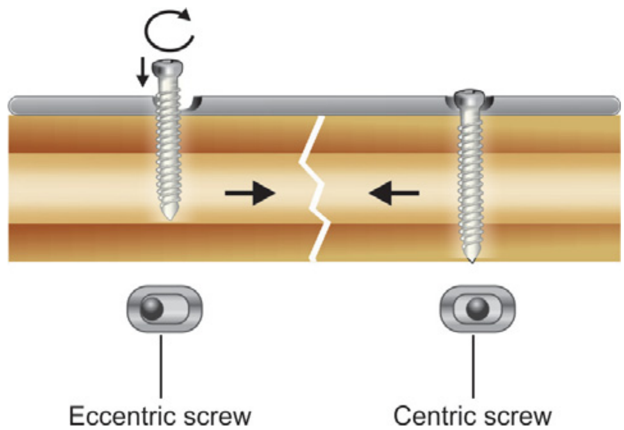


Fig. 22.2D Compression (dynamic) mode of plating

collapsing during healing process. The large surface area of plate facilitate wider distribution of loads.

- *Implant:* T, L or hockey shaped, etc—precontoured implant.
- *Plate application:* Plate force is perpendicular to offset of bone. The first screw lies closest to the fracture site on shaft hence firmly anchor the main fragment.
- *Used:* For periarticular or intra-articular metaphyseal fracture.

– *Compression mode (Fig. 22.2D)*:
  - *Function:* It produces compression forces across the fracture site.
    - If fracture is reduced anatomically; plate partially shares the load until fracture heals—finally fracture united.
    - If fracture is not reduced anatomically; entire load is shared by plate and finally implant failure occur. The technique for achieving compression are: (i) eccentric screw placement (ii) Müller's compression device.
  - *Implant:* Dynamic compression plate (DCP) or limited contact dynamic compression plate (LCDCP); these plates can provide two types of compression
    - *Static compression:* Plate applied under tension produces static compression. Static compression constantly exerted either limb is resting or functional
    - *Dynamic-compression:* Here plate can modify the physiological destabilizing forces into compressive forces.
  - *Plate application:* Plate is applied over tensile surface of bone. Order of screw application during dynamic compression plating:
    - First centric screw by the one side of fracture
    - Second eccentric screw by the other side of fracture.
    - Remaining screw will be centric.
  - *Used*: For transverse and short oblique fractures.

DYNAMIC COMPRESSION PLATES: (ALLGOWER 1960) (FIG. 22.3)

- *Classification:*

DCP type	*Width of plate*	*Screw diameter*	*Commonly used for*
Small DCP	10 mm	3.5 mm	Radius and ulna
Narrow DCP	12 mm	4.5 mm	Humerus and tibia
Broad DCP	16 mm	4.5 mm	Femur

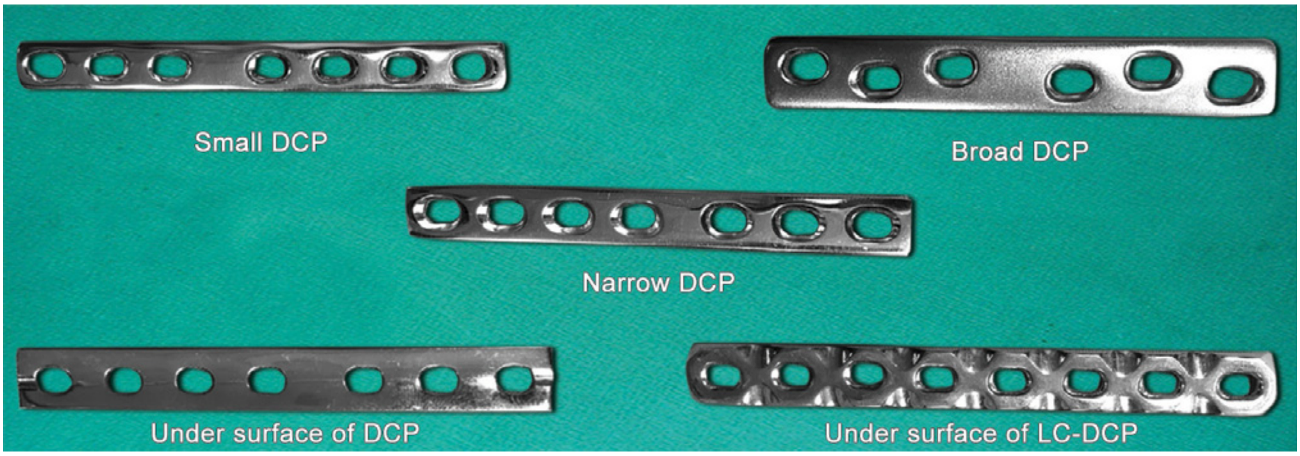


Fig. 22.3 Dynamic compression plates (DCP)

Comparison between DCP and limited contact DCP (LC-DCP)

	DCP	*LC-DCP*
Under cuts	Absent	Present
Hole distance	Even	Uneven
Bending force distribution	Even	Uneven
Cross section and stiffness	Minimum at plate hole	Uniform
Blood supply	More affected	Minimally affected
Magnitude of compression	Less	More
Bone ingrowth at fracture site	Less	More
Stress riser	More	Less
Stress shielding	More	Less
Lag screw placement freedom	25° longitudinal and 7° sideway	40° longitudinal and 7° sideway

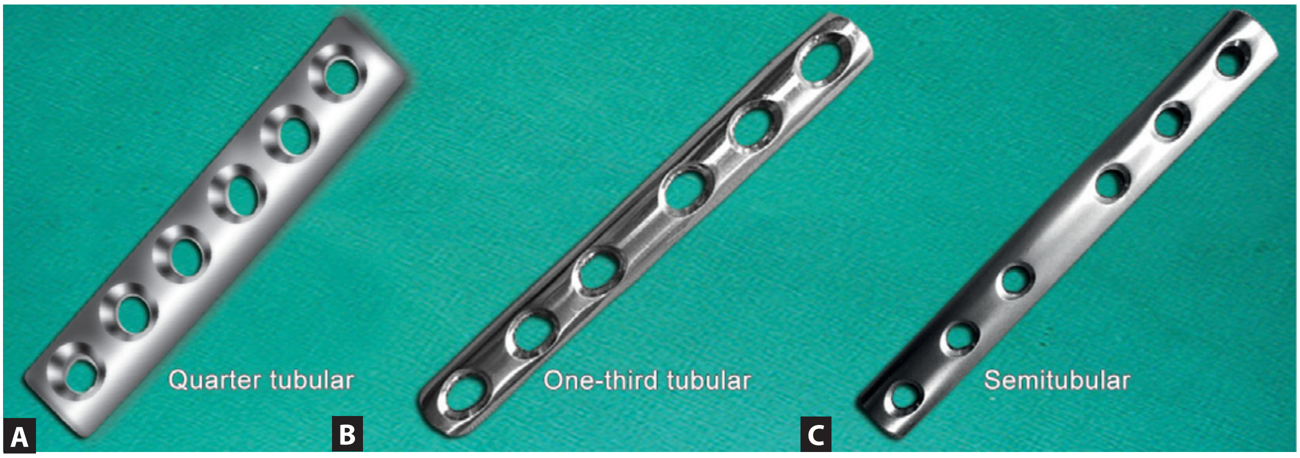
TUBULAR PLATES (FIGS 22.4A TO C)

- These plates are actually part of a metallic cylindrical tube.
- Mainly used in bridging and neutralization mode.
- *Classification:*

Plate type	*Circumference*	*Screw diameter*
Quarter tubular	1/4th circumference of cylinder	2.7 mm
One-third tubular	I/3rd circumference of cylinder	3.5 mm
Semi-tubular	1/2 circumference of cylinder	4.5 mm

LOCKING PLATE (FIGS 22.5A AND B)

- *Definition:* A fixed angle construct where screw head is locked with plate.
- *Principle:*
  - *Internal external fixator:* Do not require friction between plate and bone for stability unlike DCP.
  - *Stability occur at screw plate interface:* Increases pull-out strength of screw.
  - *No contact between plate and bone:* Do not hamper periosteal vascularity.
- *Healing of fracture:* By secondary intention; Perren strain 2–10%.
- *Plate length:* At least 3 times of fracture length.
- *Number of screw:* Only 30–40% of total screw.
- *Placement of screw:* Farthest screw first and alternate placement.



Figs 22.4A to C Tubular plates

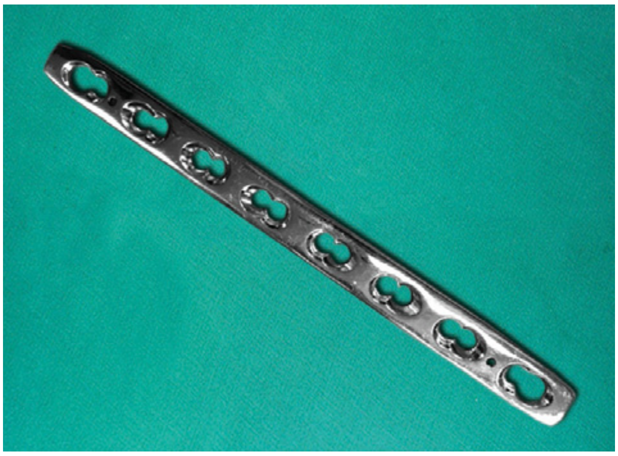


Fig. 22.5A Locking plate

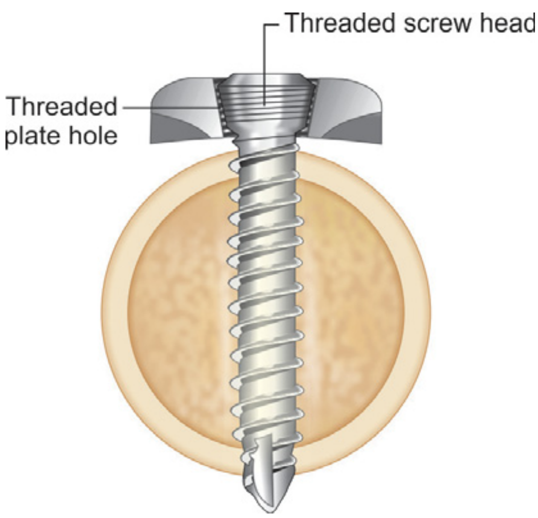
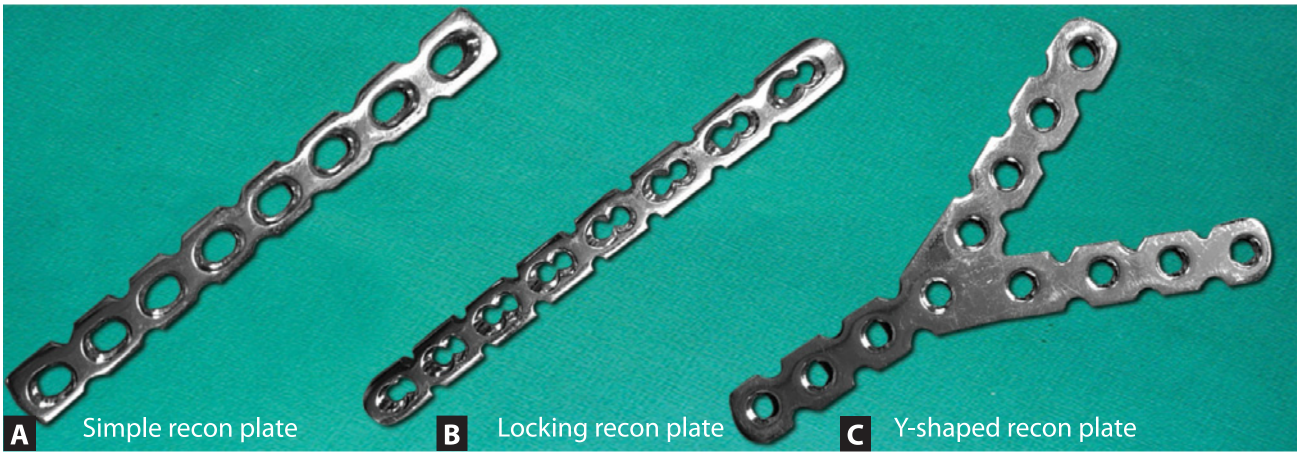


Fig. 22.5B Locking screw in locking plate

- *Mode of use:* LCP can be used in all modes such as bridging, neutralization, buttress and compression mode (some time).
- *Prerequisite:* Fracture should be completely reduced.
- *Methods of application:*
  - Open
  - Less invasive stabilization system (LISS)
- *Indications:*
  - Osteoporotic fracture
  - Comminuted metaphyseal fracture
  - Intra-articular fracture.
  - Comminuted fracture.
- *Complication:* Nonunion if not applied properly.

RECONSTRUCTION PLATES (FIGS 22.6A TO C)

- *Definition:* These plates can be molded manually according to contour of bone having fracture.
- *Mode of use:* Bridging and neutralization mode.
- *Types:*
  - *Simple recon plate:* Screw 2.5 mm, 3.5 mm, 4.5 mm
  - *Locking recon plate:* Screw 3.5 mm, 4.5 mm
- Recon plates are available in various shapes also.



Figs 22.6A to C Reconstruction plates

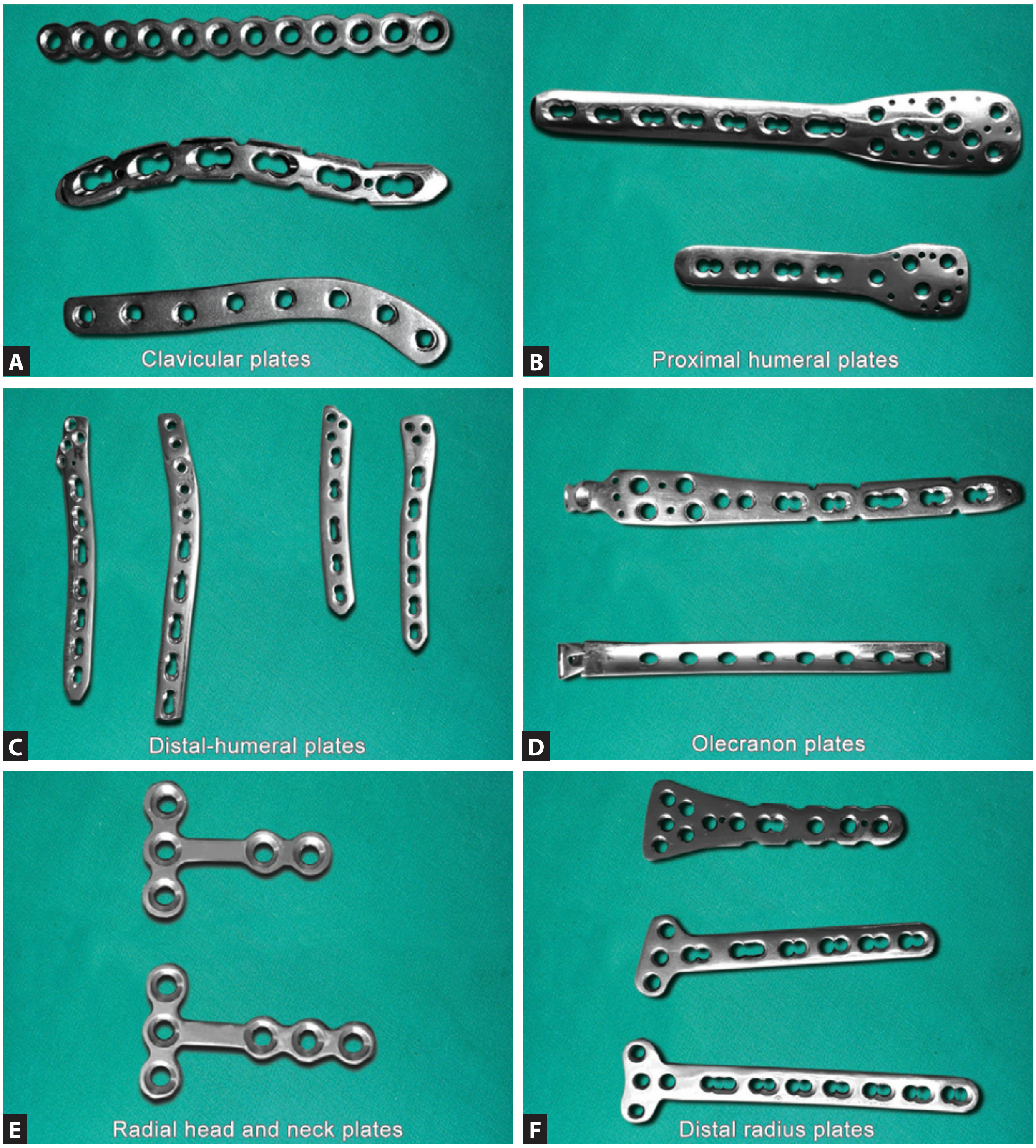
STRESS AND STRAIN IN RELATION TO BONE AND IMPLANT

- *Stress riser:*
  - Stress is an internal force which resist deformation. At a point where this stress is reasonably higher is called stress risers.
  - Stress is concentrated at a meeting point of two different anatomy such as:
    - Angulation of bone
    - Holes in plates
    - Grooves
    - Bone screw interface
    - End of the plates, etc.
  - These stresses weaken the bone part and may lead to fracture, e.g. fracture near callus, fracture at ends of plates, etc.
- *Stress shielding:*
  - When a implanted is loaded specially weight-bearing implant, it produces osteopenia of bone just beneath the implant. This effect is called stress shielding. Why so?
  - When static forces at bone implant interface is lesser than loading forces, it leads to produce a micromotion at bone implant interface and finally osteopenia of underlying bone.
- *Perren strain theory:* When the fractured bone is immobilized, the relative movement of two fragments depends upon:
  - Stiffness of implant
  - Magnitude of external loading
  - Stiffness of bridging calluses.

    The capacity to tolerate the deformation of calluses (granulation tissue) at fracture site varies according to the nature of healing at fracture site. This deformation or strain is expressed in percentage.
    - Strain 2%, i.e. healing by primary intention.
    - If strain 2–10%, healing by secondary intention.
    - If strain 10–30%, it is threshold level for healing.
    - If strain >30%, bone resorption and nonunion occur.

VARIOUS REGIONAL PLATES (FIGS 22.7A TO L)

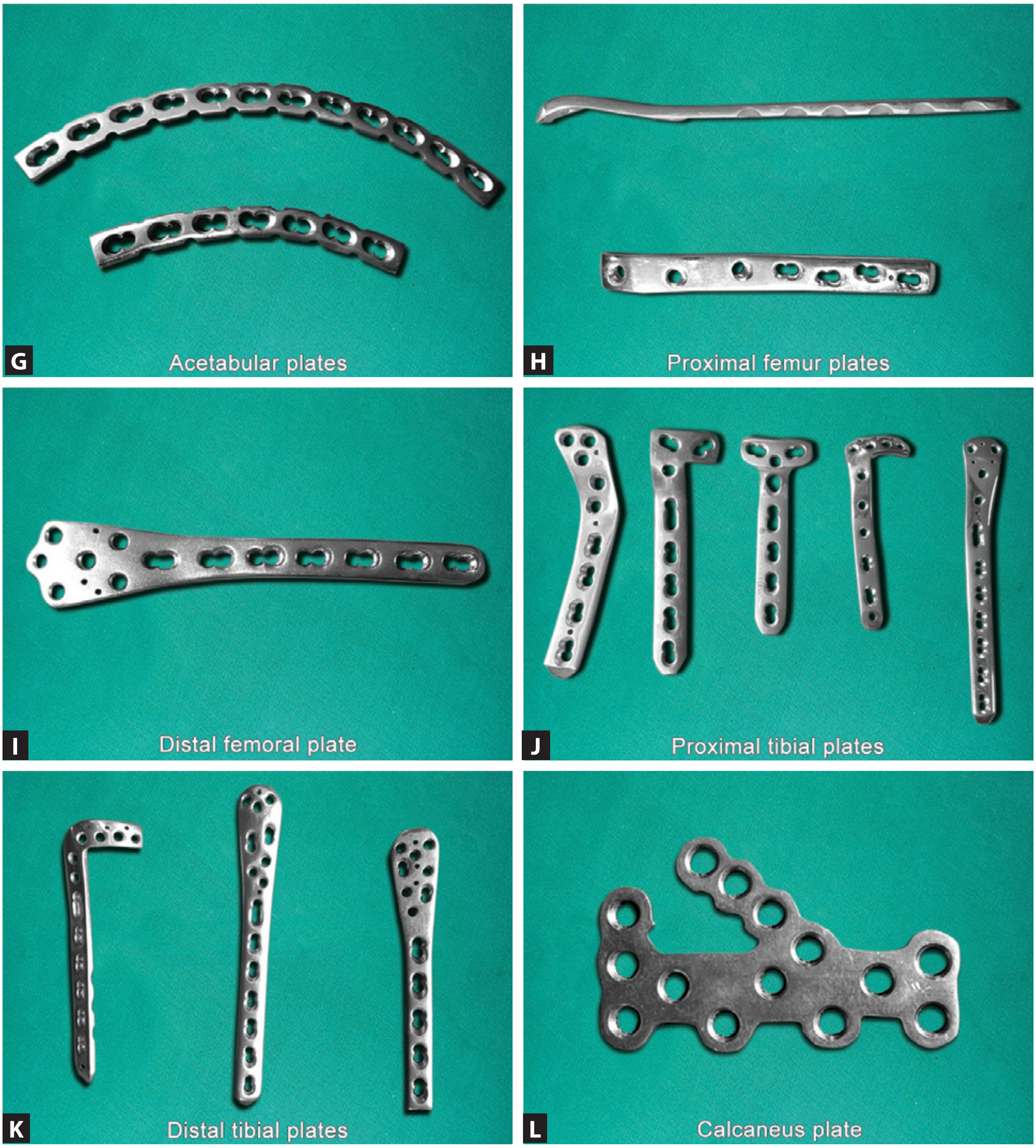
- Clavicular plate
- Proximal humeral plate
- Distal-humeral plates
- Olecranon plates
- Radial head and neck plate
- Distal radius plates
- Acetabular plates
- Proximal femur plate
- Distal femoral plate
- Proximal tibial plates
- Distal tibial plates
- Calcaneus plate



Figs 22.7A to F

☑ *Note*: Two types of plating for fracture intercondylar humerus:

1. *Orthogonal plating*: if medial plate is kept over medial supracondylar ridge and lateral plate is placed over posterior aspect of lateral column; here both screws direction are perpendicular to each other; arrangement is called orthogonal plating.
2. *Parallel plating*: Here plates are kept over both medial and lateral supracondylar ridges and both screws direction are parallel to each other; arrangement is called parallel plating.



Figs 22.7G to L

Figs 22.7A to L Various regional plates

CHAPTER

23

Orthopedic Nailing

INTRAMEDULLARY NAIL

- *Definition*: Nail is an internal splint that allows axial forces to be transmitted from on end of bone to other. This is a load sharing implant.
- *Classification:*
  - *Centromedullary nail:* For example, K-nail, V-nail
  - *Cephalomedullary nail:* For example, proximal femoral nail
  - *Condylocephalic nail:* For example, Ender's nail
  - Interlocking nail.
- *Cross section of nail:*

Cloverleaf	K-nail
V-shaped	V-nail
Square shaped	Talwalkar square nail

☑ *Note:* Diamond-shaped cross-section have greatest bending strength.

- *Generation of nail:*
  - *1st generation nail:* Only internal splintage but no rotational stability, e.g. K-nail, V-nail.
  - *2nd generation nail:* Rotational stability with, entry from piriformis fossa, e.g. interlocking nail
  - *3rd generation nail:* Trochanteric entry, e.g. PFN, recon nail.
- *Working length of nail:*
  - *Definition:* Distance between two points on either side of fracture where metal firmly grips the bone.
  - *Working length determines:*
    - *Bending stiffness:* It is inversely proportional to square of working length.
    - *Torsional stiffness:* It is inversely proportional to working length.
- *Hoop stress:*
  - *Definition:* When a nail is inserted into medullary canal, a circumferential expanding force generated on cortex of bone is called hoop stress. This may lead to fracture of bone.
  - How to reduce hoop stress?
    - Over-reaming of canal
    - Use undersize nail
    - Flexible nail
    - Proper entry point.
- *Dynamization of nail:*
  - *Definition:* The production of micromovement at fracture site without any deformation when limb is loaded is called dynamization.
  - *When:* 6–10 weeks after fracture fixation.
  - *Prerequisite:* Minimal callus around fracture site.

– *How:* Removal of static bolt from longer fragment (for minimal instability).

RUSH NAIL (FIG. 23.1)

- *Parts of nail*: A centromedullary nail
  – *One end having beveled tip:* For easy migration in medullary cavity.
  – *Another end having hook:* Prevent inward migration of nail in medullary cavity and for easy extraction.
  – *Cylindrical shaft:* No rotational stability.
- *Principle:* Three point fixation
- *Uses:* For fracture fibula, fracture both bone forearm, fracture humerus
- *Disadvantages:*
  – No rotational stability.
  – No locking mechanism.
- Commonly available in 2–4 mm diameter (variation 0.5 mm) of various length.

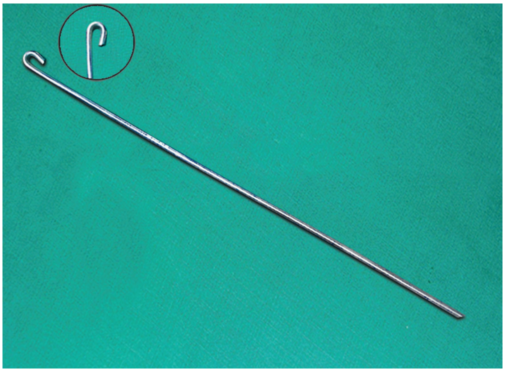


Fig. 23.1 Rush nail

TALWALKAR'S SQUARE NAIL (FIG. 23.2)

- *Parts of nail:* A centromedullary nail
  – *One end threaded:* For insertion and extraction of nail.
  – *Another end:* Tongue shaped (radius square nail) and trocar tipped (ulnar square nail)
  – *Square shaped shaft:* Partial rotational stability.
- *Principle:* Three point fixation
- *Uses:* For fracture both bone forearm, fracture fibula, fracture humerus
- *Disadvantages:*
  – Do not provide rotational stability.
  – No locking mechanism.
- Commonly available in 1.5–6.5 mm diameter (0.5 mm variation) of various length.

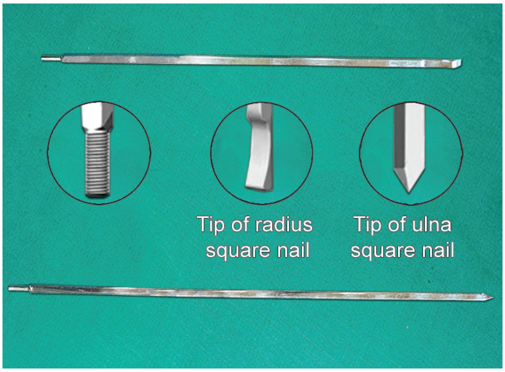


Fig. 23.2 Talwalkar's square nail

ENDER'S NAIL (FIG. 23.3)

- *Parts of nail*: A condylocephalic nail.
  – *One end flattened with an eye:* For insertion and extraction of nail.
  – Another end blunt.
  – *Square-shaped shaft:* Partial rotational stability.

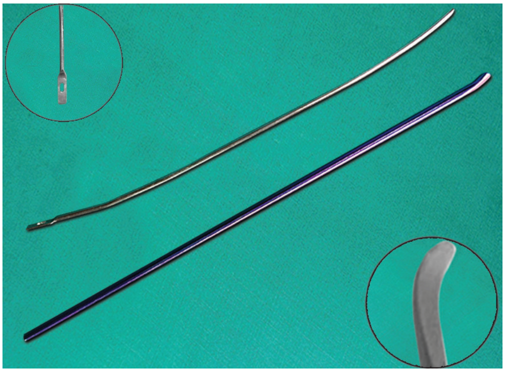


Fig. 23.3 Ender's nail

- *Principle:* Three point fixation
- *Uses*
  – For fracture shaft of femur, for fracture tibia, fracture humerus

- *These implants were primarily used for fracture fixation in trochanteric and sub trochanteric area of femur*
- *Disadvantages:*
  - Do not provide rotational stability.
  - No locking mechanism.

Titanium elastic nail (TEN) • A straight nail slightly curved and flattened at one end.
• Should occupy 30–40% of medullary cavity.
• Diameter of nail (Flynn formula) = width of narrowest point of medullary canal × 0.4
Commonly available in 2–4.5 mm diameter (variation 0.5 mm) of various length.

KUNTSCHER'S CLOVERLEAF NAIL: (GERHARD KUNTSCHER FROM GERMANY) (FIG. 23.4A)

- *Anatomy of nail:* A centromedullary nail
  - *Two blunt ends with eye:* Blunt end reduces chance of cortex penetration
  - *A hollow shaft:* Allows bone marrow continuity and guidewire passage if needed.
  - *Cloverleaf cross-section:* Provide some rotational stability.
  - *Eye:* For nail extraction
- *Principle:*
  - *Three point fixation:* Two ends in metaphysis and one at isthmus.
  - *Longitudinal slot:* Lies anterolaterally and allows bend along tensile surface of bone.
  - *Longitudinal metal bar opposite to slot:* Accommodate body weight along compressible surface of bone (Fig. 23.4B).
- *Determination of length:*
  - Tip of greater trochanter to knee joint line-2 cm.
  - Tip of greater trochanter to upper pole of patella.
  - Greater trochanter to metaphyseal scar (seen in X-ray)
- *Method of nail insertion:*
  - Reterograde entry:

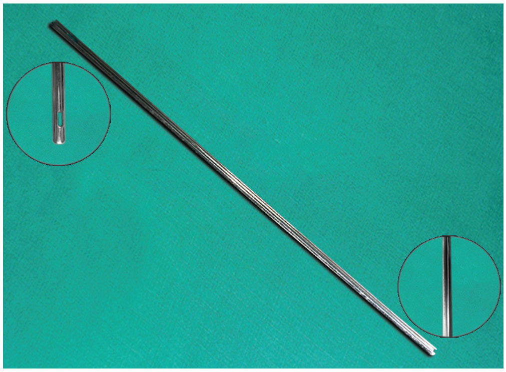


Fig. 23.4A Kuntscher's cloverleaf nail

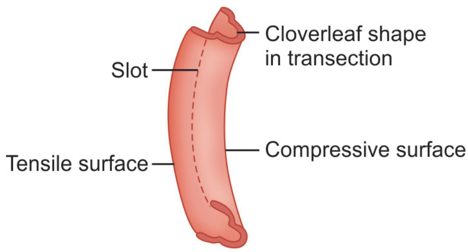


Fig. 23.4B Effect of loading on cloverleaf nail

  - Anterograde entry (piriformis fossa)
- *Disadvantages:*
  - Do not provide rotational stability.
  - No locking mechanism.
- *Complication with K-nailing:*
  - Splintering of cortex
  - Proximal and distal migration of nail
  - Stucking of nail
  - Nail bending and breakage
  - Knee joint stiffness.
- Commonly available in 6–15 mm diameter (variation 1 mm) of various length.

KUNTSCHER'S V NAIL (FIG. 23.5)

- *Anatomy of nail:* A centromedullary nail
  - Blunt upper end with eye
  - V shaped shaft with slot
  - Beveled distal end
  - *Cross-section:* V-shaped, slight rotational stability.
  - *Eye:* For nail extraction

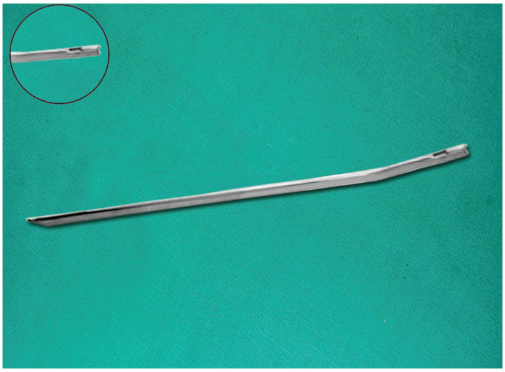
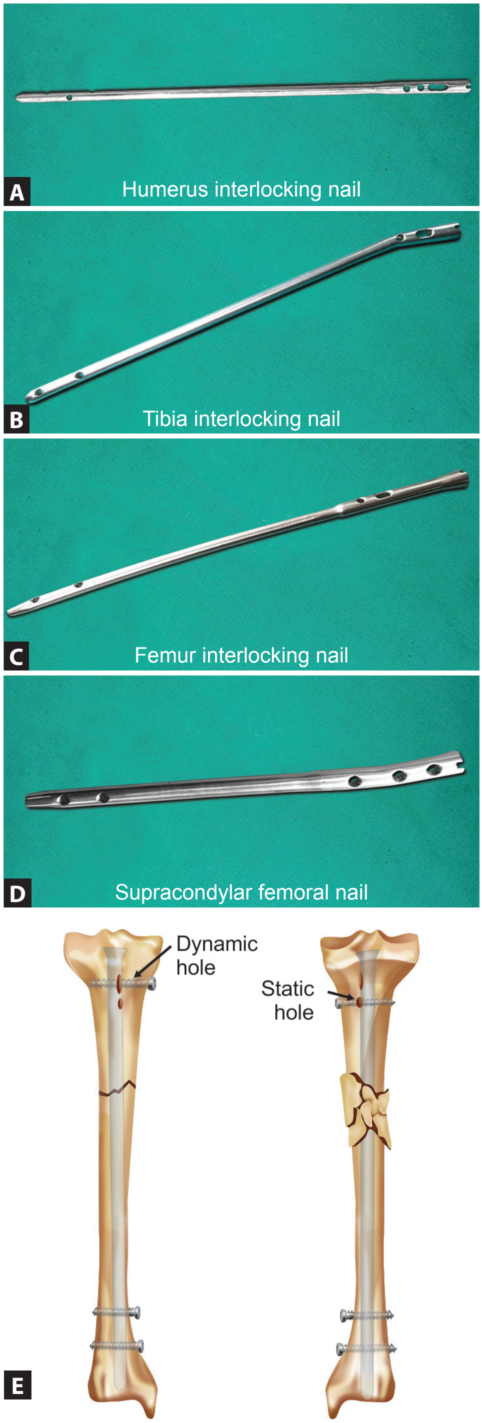


Fig. 23.5 Kuntscher's V nail

- *Bend and angulation:* Herzog bend 20° and distal bend 5° with apex posteriorly.
- *Principle:* 3-point fixation, slot lies posteriorly and eye anteriorly.
- *Determination of length:* Tibial tuberosity to tip of medial malleoli –2 cm.
- *Entry point:*
  - 1–1.5 cm distal to knee joint line in the line of medial half of tibial tuberosity.
  - A triangular slope above tibial tuberosity.
- *Disadvantages:*
  - Do not provide rotational stability.
  - No locking mechanism.
- Commonly available in 6–12 mm diameter (1 mm variation) of various lengths.

INTERLOCKING NAIL (FIGS 23.6A TO E)

- **Modney** (Germany) was pioneer of interlocking nailing.
- These are cylindrical nails of various bends and angulations with proximal and distal holes for bolts.
- *Principle:* 3-point contact.
- *Mode of use:*
  - If only dynamic bolts are applied; it act as load sharing implant, e.g. useful in transverse or short oblique fractures.
  - If only static bolts are applied; it act as load bearing implant, e.g. useful in comminuted fractures.



Figs 23.6A to E Working mode of interlocking nail

Comparison of various types of interlocking nails

	Humerus interlocking nail	*Tibia interlocking nail*	*Femur interlocking nail*	*Supracondylar femoral nail*
Hole: Proximal-dynamic/static distal-mediolateral/anteroposterior	 3—1/2 1/2	 2—1/1 2/1	 2—1/1 2/0	 3 2/0
Bend and angulation	5–6° lateral bend	10° post-Herzog's bend 5 cm away from proximal end	Anterior bowing	Anterior bend 4 cm away from proximal end
Diameter	6–8 mm diameter of various length	7–12 mm diameter	8–13 mm diameter	9–13 mm diameter
Bolt	Mediolateral—2.9 mm Anteroposterior—3.4 mm	• Up to 8 mm diameter nail—3.9 mm • For 9 mm or more diameter nail—4.9 mm	• Up to 8 mm diameter nail—3.9 mm • For 9 mm or more diameter nail—4.9 mm bolt	5 mm
Entry point of nail	Medial to tip of greater tuberosity and 0.5 cm behind bicipital groove	• 1–1.5 cm distal to knee joint line in the line of medial half of tibial tuberosity • Through a triangular slope above tibial tuberosity	Through piriformis fossa	• Centrally between two condyles in the intercondylar notch. • 1 cm anterior to insertion of PCL

Comparison of reamed and undreamed nailing

	Reamed nailing	*Unreamed nailing*
Nail diameter	Larger diameter	Lesser diameter
Working length (WL)	Increase working length	No change in working length
Stability	More	Lesser
Endosteal or medullary blood supply	Hampered	Intact
Healing of fracture	Periosteal callus	Both periosteal and endosteal callus
Thermal necrosis	Present	Absent
Bone graft at fracture site	Present	No
Risk of fat embolism	Present	No
Chances of infection	More chances	No
Use in compound fracture	No	Yes

CHAPTER

24

Special Implants Around Hip

AUSTIN MOORE'S PIN AND KNOWLES PIN (FIG. 24.1)

Comparison between Austin Moore's pin and Knowles pin		
	Austine Moore's pin	*Knowles pin*
Diameter	3 mm	4 mm
Length	50–150 mm at interval of 5 mm	50–130 mm at interval of 5 mm
End	Advancing half smooth and rear half threaded	Advancing end threaded and rest length of pin smooth
Nut and stopper	2 mobile washer	One immobile stopper

- Used in pediatric fracture neck of femur.

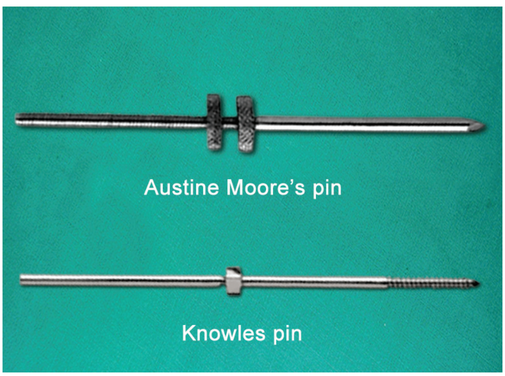


Fig. 24.1 Austine Moore's pin and Knowles pin

CANNULATED CANCELLOUS HIP SCREW (FIGS 24.2A AND B)

- *Screw description:*
  - Partially threaded, cannulated and cancellous screw.
  - *Diameter*: 6.5 mm and 7.0 mm.
  - *Diameter of guidewire used*: 2.0 mm.
- *Use:* Fracture neck of femur where physis are fused.
- *Screw configuration:*
  - Reverse triangle—why most common? Due to maximum bone density area.
  - *Diamond configuration*: For communited fracture.
- *Screw placement:*
  - Parallel to each other; neither converging nor diverging.

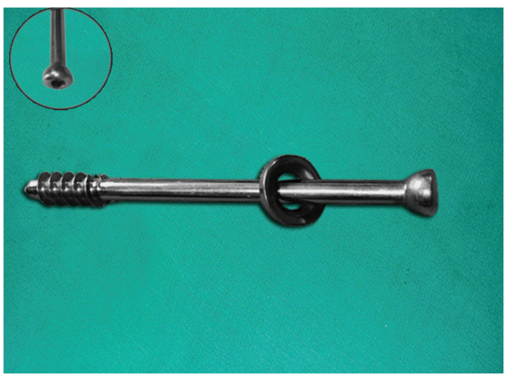


Fig. 24.2A Cannulated cancellous screw with washer

 – Within 3 mm of cortex of neck of femur not intramedullary.
- *Order of screw placement:*

Order of screw placement	*Location*	*Function*
1st	Infero-central	Prevents varus
2nd	Postero-superior	Prevents retroversion—if more posterior may hamper the blood supply of posterosuperior branch of retinacular artery
3rd	Antero-superior	More prone to back out

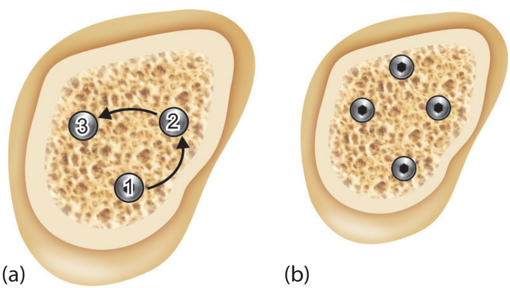


Fig. 24.2B Geometry and order of screw placement: (a) Reverse triangle pattern; (b) Diamond configuration

Fig. 24.3A Dynamic hip screw (DHS) plate

DYNAMIC HIP SCREW (DHS) PLATE (FIGS 24.3A AND B)

- *Barrel:*
  - Short barrel—25 mm.
  - Standard barrel—38 mm.
  - Barrel inner diameter—8.2 mm.
  - Barrel outer diameter—12.5 mm.
- *Plate:*
  - 4.5 mm screw.
  - Hole arrangement—staggered. Why?
    - Even distribution of stress over plate and bone when limb is loaded.
    - Hence, prevent implant breakage and weakening of bone.
- *Angle between barrel and plate:* 130° and 135° (commonly available).
- *Sliding screw:*
  - Screw length—50–130 mm at interval of 5 mm.
  - Core diameter—8 mm.
  - Thread length—22 mm.
  - Thread diameter—12.5 mm.

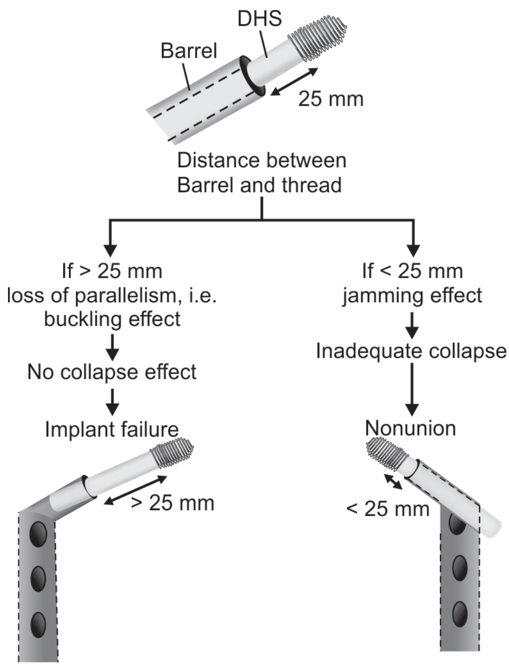


Fig. 24.3B Mismatching of sliding distance

- *Sliding screw versus Richard screw:*
  - Shaft of sliding screw is rectangular with rounded corner in cross-section, so that it fits in slot of barrel of DHS plate hence it prevents the rotation of screw in barrel and finally stabilizes the fracture.
  - *What is Richard screw:* It is ancestor of DHS sliding screw, its shaft is cylindrical with a longitudinal slot with a provision for fitting in barrel of plate but was insufficient to prevent the rotation.
- *Sliding distance (SD):* Optimum 25 mm (Fig. 24.3B)
  - What happens if SD >25 mm.
    - Loss of parallelism between barrel and sliding screw.
    - Buckling effect and implant failure.
  - What happens if SD <25 mm.
    - Jamming occur at interface of barrel and sliding screw.
    - Prevents collapse at fracture site.
- *Indication of standard and short barrel DHS plate.*
  - *Hence, minimum length of DHS screw should be calculated as:* Thread length+ optimum sliding distance + standard barrel length, 22 + 25 + 38 = 85 mm.
  - *Standard barrel:* When length of DHS screw is 85 mm or more.
  - *Short barrel:* When length of DHS screw is less than 85 mm.
- *Mode of action:* Sequential collapse at the fracture site when joint is loaded.
- *Uses:*
  - Intertrochanteric fracture.
  - Basal neck fracture.
  - Sometime in valgus osteotomy when wedge is less than 20°.
- *Modification of DHS plate:*
  - Trochanteric stabilization plate (TSP).
  - Medoff's plate.

DYNAMIC CONDYLAR SCREW (DCS) PLATE (FIG. 24.4)

- Designed originally for supracondylar/ intercondylar # femur.
- *Barrel length:* 25 mm.

Fig. 24.4 Dynamic condylar screw (DCS) plate

- *Plate hole:* 4.5 mm.
- *Angle between barrel and plate:* 95°
- *Proximal bend:* To accommodate the contour of greater trochanter.
- *Screw:* As sliding screw (but no sliding mechanism).
- *Mode of action:* Neutralization plate.
- *Uses:*
  - Reverse oblique type intertrochanteric fracture.
  - Subtrochanteric fracture.

COMPARISON BETWEEN SHORT AND LONG PFN (FIGS 24.5A AND B)

	Short PFN	*Long PFN*
Hole; proximal/ distal	Mediolateral 2/2 holes	Mediolateral 2–4/2–3 holes
Bend and angulation	5–7° lateral bend	3–5° lateral bend with anterior bowing
Diameter	9–12 mm	9–12 mm
Length	24 cm	30–50 cm
Bolts	Bolt in neck 6.5 mm–upper and 8.0 mm–lower/bolt in shaft 4.9 mm	Bolt in neck 6.5 mm–upper and 8.0 mm–lower/bolt in shaft 4.9 mm
Entry point	Tip of greater trochanter or sometimes slight medial entry point	Through piriformis fossa slight anteriorly at the junction of anterior 2/3rds and posterior 1/3rd

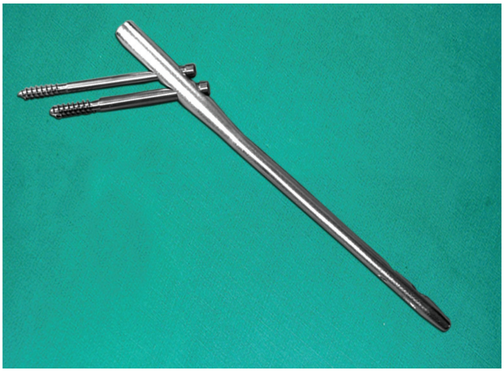


Fig. 24.5A Short PFN

Fig. 24.5B Long PFN

- *Reconstruction nail:*
  - It is a modification of long PFN.
  - It proximal most diameter is more than PFN.
  - It has a provision for bolt for both femoral neck and proximal femur.
  - Lateral entry variant of Recon nail is also available (AO).

ANGLED BLADE PLATE (130° AND 95°) (FIG. 24.6)

- This is a type of condylar plate with a blade and stem.
- *Blade length:* 50–100 mm at difference of 5 mm.
- *Blade width:* 16 mm.
- *Plate hole for:* 4.5 mm screw.
- *Angle between blade and stem of plate:* 130° and 95°.
- *Proximal bend:* To accommodate the contour of greater trochanter.
- *Mode of action:* Neutralization plate
- *Uses of blade plate:*
  - 130 blade plates used for intertrochanteric fractures
  - 95 blade plates are used for reverse oblique intertrochanteric fracture, subtrochanteric fracture and supracondylar fracture of femur.

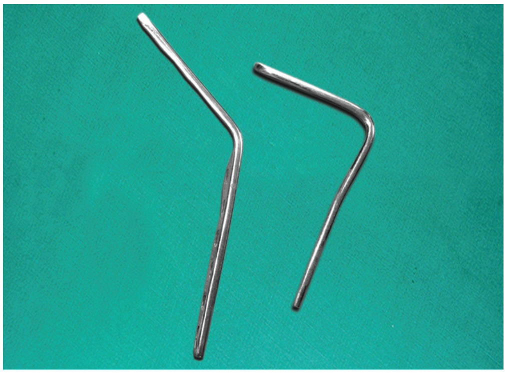


Fig. 24.6 Angled blade plate (130° and 95°)

IDENTIFICATION OF SOME HISTORICAL IMPLANTS (FIGS 24.7A TO D)

- Garden's screw.
- Smith-Peterson nail and McLaughlin plate.
- Zewett plate.
- Gamma nail.

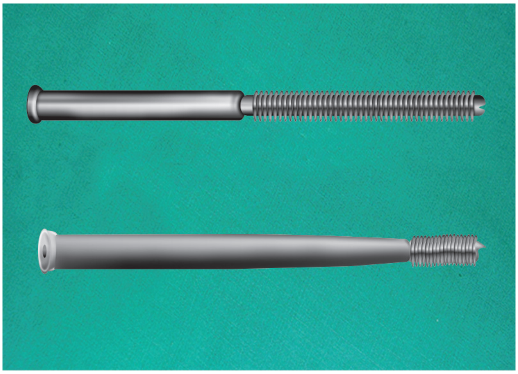


Fig. 24.7A Garden's screw

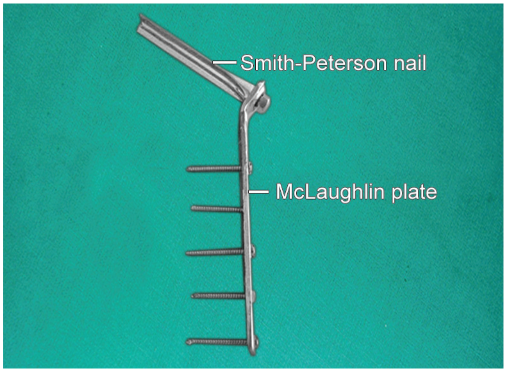


Fig. 24.7B Smith-Peterson nail and McLaughlin plate

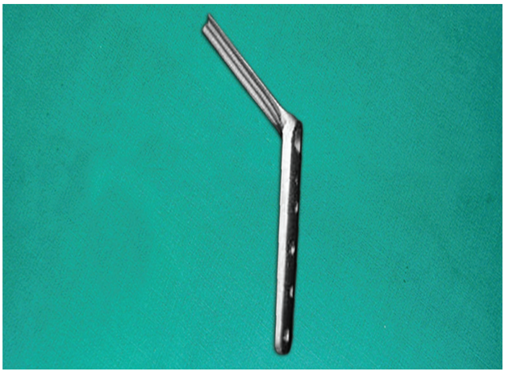


Fig. 24.7C Zewett plate

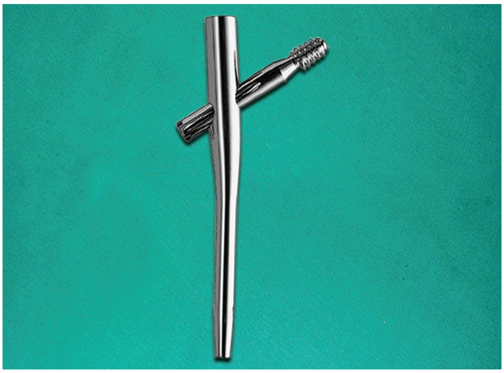


Fig. 24.7D Gamma nail

CHAPTER

25 Spinal Implantation

STEFFEE SPINE PLATE AND SCREW (FIG. 25.1)

- It looks like a locking dynamic compression plate (DCP)
- *Plate hole for:* 4.5 mm screw.
- Commonly available in 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0 holes.
- It is used in Pairs by the side of spinous process spanning the affected vertebrae.

HARTSHILL RING/FRAME AND DRUMMOND WIRE (FIG. 25.2)

- It is a rectangular ring with a curvature in two smaller arm.
- *Two types ring:* Plain or serrated.
- Commonly available length 5–20 cm at difference of 1 cm.
- Ring is placed longitudinally so that both long arms are placed over the lamina of vertebrae and concavity of smaller arm lies across the spine.
- Ring is fixed with underlying lamina of vertebrae with stainless steel wire called sublaminar wire.
- Sublaminar wire with a button like knob is *Drummond's wire*.

HARRINGTON ROD WITH HOOK (FIG. 25.3)

- It is a straight rod with ratcheting mechanism used for scoliotic deformity correction.

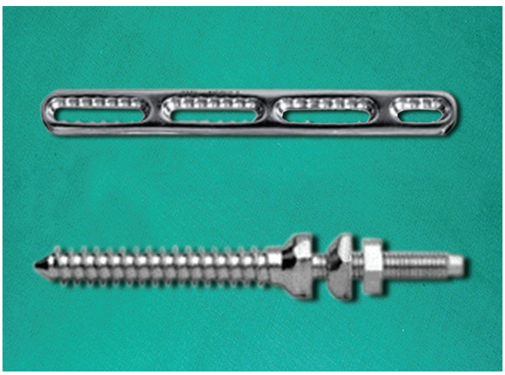


Fig. 25.1 Steffee spine plate and screw

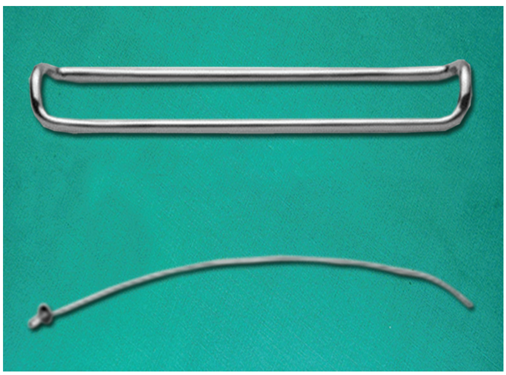


Fig. 25.2 Hartshill ring/frame and Drummond wire

- Commonly available size are 2.5–30 cm at difference of 2.5.
- Rod is placed in concavity of scoliotic curve and spine is straighten by using the ratcheting mechanism.
- Two hooks (sharp or blunt) are fitted in sublaminar spaces at upper and lower ends of rod.

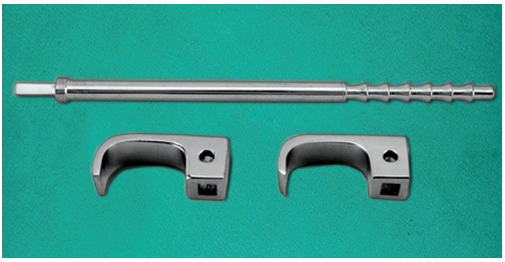


Fig. 25.3 Harrington rod with hook

PEDICULAR SCREW AND CONNECTING ROD (FIGS 25.4A AND B)

- As the name suggest it is special screw which takes its hold in pedicle and body of spine and provides strong anchorage to it. These pedicular screw can be connected with rod each side of spinous processes.
- *Parts of screw:*
  - *Head:* Has a slot for connecting rod and threads for inner screw.
  - Neck.
  - Body with self-tapping tip.
- *Three types:*
  1. Monoaxial—no freedom of movement.
  2. Poly axial—freedom of movement of 55° (15° at head and 40° in body).
  3. Reduction pedicular screw—helps in reduction in spinal listhesis.
- *Commonly available sizes:*
  1. For thoracic spine (diameter 4.0, 4.5 mm and length 25, 30, 35, 40 mm).
  2. For lumbar spine (diameter 4.5, 5.5 mm and length 35, 40, 45, 50 mm).
- Used for segmental spinal fusion and deformity correction.
- *Connecting rod:* Commonly used diameter is 5.5 mm of various length.

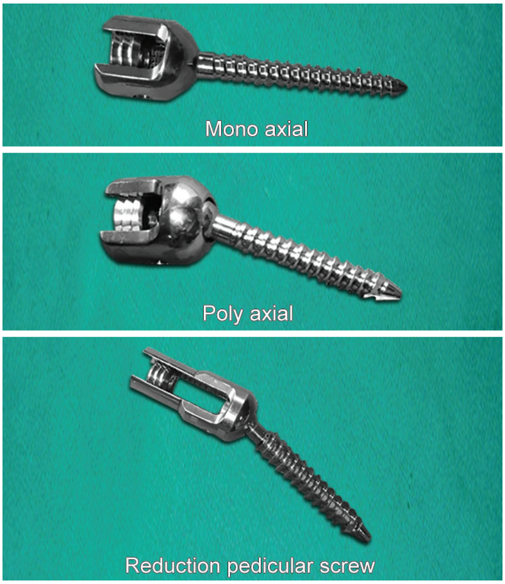


Fig. 25.4A Pedicular screw

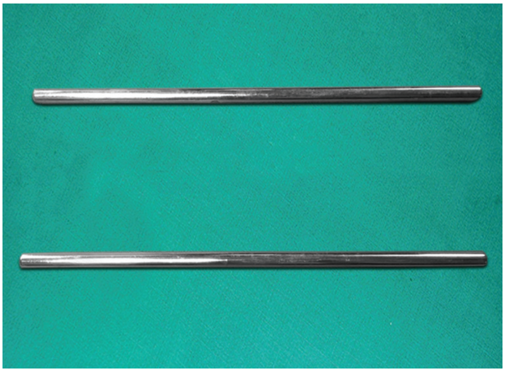


Fig. 25.4B Pedicular screw connecting rod

ANTERIOR SPINAL LOCKING PLATE AND SCREW (FIG. 25.5)

- *Characteristic of implant:*
  - These are locking plate with two adjacent hole for one vertebral body.
  - There is defect (some design) in between the two sets of hole to hold the bone graft.

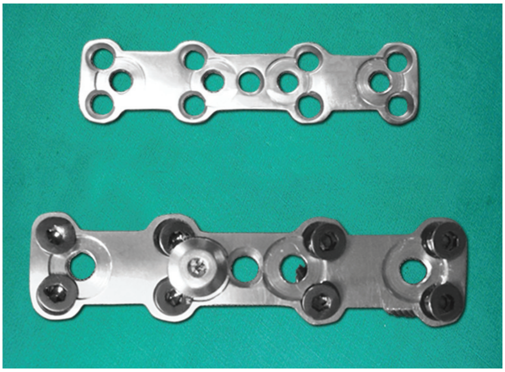


Fig. 25.5 Anterior spinal locking plate and screw

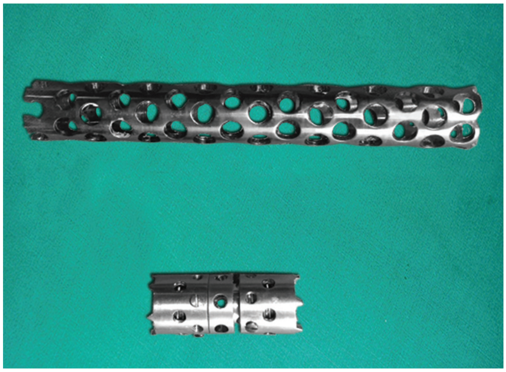


Fig. 25.6 Spinal cage

  - The inner screw can seal the heads of locking screw with plate.
- *Commonly available sizes:*
  - *Plate hole for:* 3.5, 4.5 mm screw.
  - *Screw length:* 12–16 mm at 1 mm increment.
- Used commonly for cervical spine stabilization.

SPINAL CAGE (FIG. 25.6)

- These are cylindrical implant with multiple holes that act as a spacer.
- Bone graft is filled in hollow of cage that creates a contact between two adjacent vertebrae and ensure the interbody fusion.
- Vertebral height can be easily maintained.
- Compressive neuropathy around affected vertebrae can be avoided.
- *Advantages:*
  - Vertebral height can be easily maintained.
  - Compressive neuropathy around affected vertebrae can be avoided.

CHAPTER

26

Osteotomy Fixation and Epiphysiodesis Implants

WAINWRIGHT PLATE, KISSEL SPLINE, TUPMAN PLATE (FIGS 26.1A TO C)

- This is a medial displacement osteotomy (McMurray) fixation plate.
- It's proximal part (sharp V-shaped in transection) is inserted into greater trochanter.
- Stem of plate is fixed with medially displaced femoral shaft with 4.5 mm screw.

☑ *Note:* Historical implant to fix the **Mcmurray** osteotomy.
  - **Kissel** spline.
  - **Tupman** plate.

90° OSTEOTOMY BLADE PLATE (FIG. 26.2)

- It is an angled blade plate.
- Blade of plate makes an angle of 90° with its stem.
- There is a proximal bend in plate to accommodate the trochanteric area.
- It is used to fix various type of intertrochanteric femoral osteotomy.

Figs 26.1A to C (A) Wainwright plate; (B) Kissel spline; (C) Tupman plate

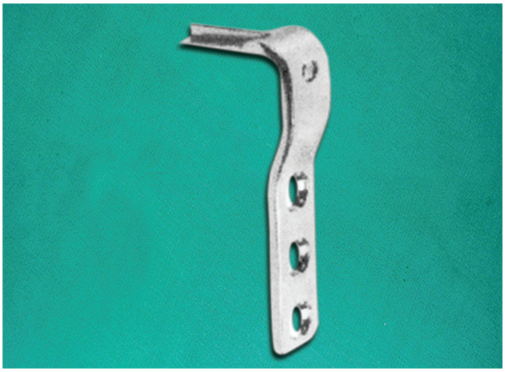


Fig. 26.2 90° osteotomy blade plate

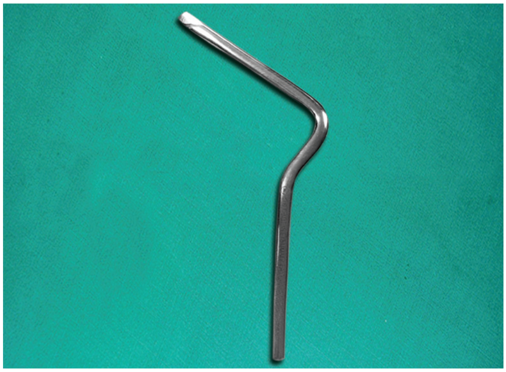


Fig. 26.3 120° double angle osteotomy blade plate

120° DOUBLE ANGLE OSTEOTOMY BLADE PLATE (FIG. 26.3)

- It is also an angled blade plate.
- Blade of plate makes an angle of 120° (95° + 25°) with its stem.
- There is a proximal bend in plate to accommodate the trochanteric area.
- It is used to fix the proximal femoral valgus osteotomy for malunited intertrochanteric fractures or nonunion femoral neck fractures.

120° DOUBLE ANGLE DHS PLATE (FIG. 26.4)

- It is a modified dynamic hip screw (DHS) which act as neutralization plate.
- Barrel of plate makes an angle of 120° (95° + 25°) with its stem.
- There is a proximal bend in plate to accommodate the trochanteric area.
- It is used to fix the proximal femoral valgus osteotomy for malunited intertrochanteric fractures or nonunion femoral neck fractures.

COVENTRY STAPLE (FIGS 26.5A TO C)

- It is a U-shaped implant with a two sharp pointed arm. There is also a step of 5 mm, 10 mm, 15 mm between the two arms.

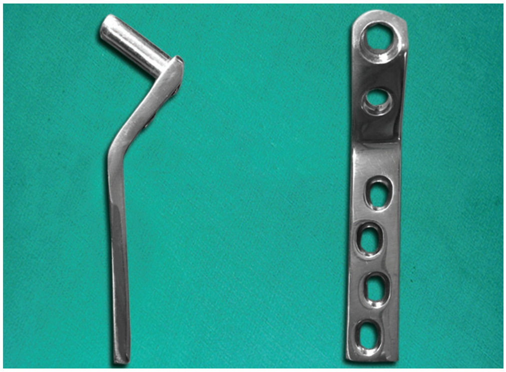


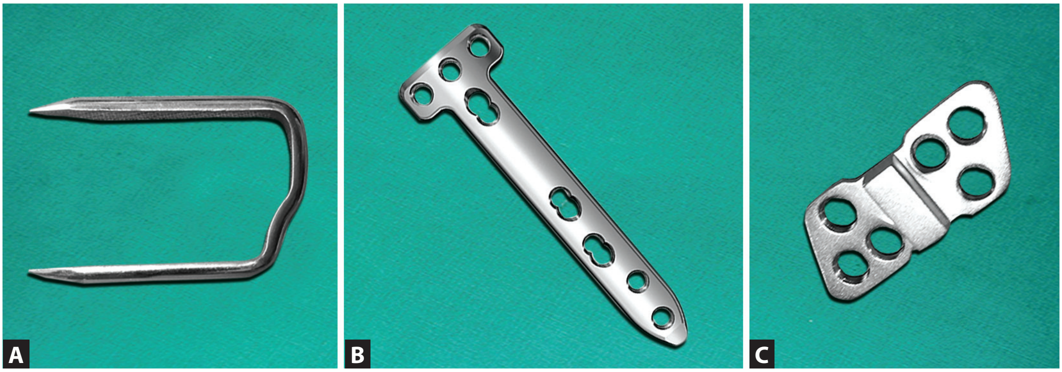
Fig. 26.4 120° double angle DHS plate

- The step in implant accommodate the step created between proximal and distal fragment at the osteotomy site.
- Used to fix proximal tibial closed wedge osteotomy during correction of varus or valgus deformity at knee.

☑ *Note:* T plates, Tomofix, **Puddu** plates are also being used for fixation of proximal tibial osteotomy.

BLOUNT'S EPIPHYSIODESIS STAPLE (FIG. 26.6)

- It is a U-shaped implant with two sharp pointed arms.



Figs 26.5A to C (A) Coventry staple; (B) Tomofix; (C) Puddu plates

- *Implant is commonly available in:*
  - Diameter—1.5 mm, 2.0 mm, 2.5 mm, 3.0 mm.
  - Width—15 mm, 20 mm, 25 mm.
- *Used for:*
  - Epiphysiodesis in distal femur and proximal tibia for correction of angular deformity at knee.
  - To fix osteotomy around knee or ankle and foot (sometimes).

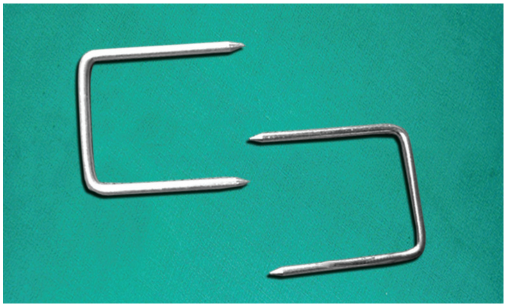


Fig. 26.6 Blount's epiphysiodesis staple

FIGURE 8 PLATE (FIG. 26.7)

- *Plate and screw:*
  - It is 8 shaped nonlocking extra-periosteal plate with 4.0 mm cancellous screw.
  - Plate hole are designed in such a manner that screw may diverge up to 45° with growth of opposite physis **(hinge action)**
  - Hinge action protect the physeal damage and side by side minimizes the chance of screw or plate failure.
  - Screws are applied by the side of physis under fluoroscopic control.
- *Variation:*
  - Two hole or four hole.
  - Prefer longer screw; smaller screw may backout.
- *Function and use:*
  - Growth modulation at growing end of femur and tibia.
  - Applied either medially or laterally or both.

Fig. 26.7 Figure 8 plate with screw

  - Corrects deformity like knee varus, valgus or recurvatum and also used for limb length discrepancy cases.

CHAPTER

27

Arthroplasty Implants

UNIPOLAR HIP PROSTHESIS: AUSTIN-MOORE AND THOMPSON PROSTHESIS (FIG. 27.1)

Comparison between Austin-Moore and Thompson prosthesis		
	Austin-Moore prosthesis	*Thompson prosthesis*
Parts of implant	• Head, neck, collar and stem	Head, neck, collar and stem
Role of collar	• Collar sits over calcar	No such provision
Holes in implant	• Collar hole for anteversion maintenance and implant removal • Two stem hole for bone ingrowth • Holes also make the implant lighter	No hole
Shoulder	• Shoulder fits at medial aspect of greater trochanter in medullary cavity and prevents rotation	No provision of shoulder
Mechanism of fixation with bone	• Fixation due to bone ingrowth	Fixation with cement
Indication	• Where calcar is left of at least 1.5 cm	Where calcar is deficient or less than 1 cm

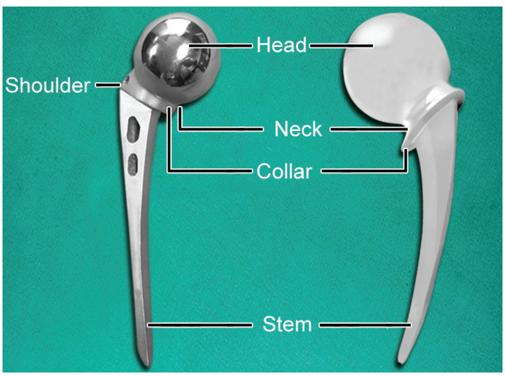


Fig. 27.1 Austin-Moore and Thompson prosthesis

- *Advantages of smooth, quadrangular and tapered end design:*
  - Easy insertion
  - Snugly fits in medullary cavity and check rotation
  - Prevent peroperative fracture of lateral cortex of femur

☑ *Note:* The stem hole of Austin-Moore prosthesis is filled with bone graft taken from extracted femoral head that induces the process of bone ingrowth.

TALWALKAR'S BIPOLAR PROSTHESIS (FIGS 27.2A AND B)

- **Bateman** was pioneer in development of bipolar prosthesis.
- *Parts of prosthesis:*
  - Head within head—big outer metallic head lined by polyethylene liner and a smaller metallic head inside it. Inner head moves in interprosthetic joint but outer head rotates in acetabulum, i.e. why it is called bipolar prosthesis
  - Neck—fixed length
  - Collar—sits over calcar
  - Stem—smooth and tapered.
- *Mechanism of fixation:* Cemented; but very frequently used as uncemented prosthesis in good bone-stock.
- Used for hemiarthroplasty hip
- *Advantages of bipolar prosthesis:*
  - Increased range of motion
  - Less acetabular wearing.

Fig. 27.2A Talwalkar bipolar prosthesis

Fig. 27.2B Modular bipolar prosthesis

☑ *Note:* Is it truly a bipolar prosthesis? It is proved in various studied that articulation between outer and inner head is lost in few months (3 months) after surgery and bipolar prosthesis becomes unipolar. To overcome this issue bicentric-bipolar prosthesis have been designed.

Modular Bipolar Prosthesis

- It is a device in between bipolar prosthesis and cemented total hip arthroplasty system.
- Similarity with bipolar prosthesis:
  - *Motion at two sites:* One at interprosthetic articulation and second at interface of outer head and acetabulum.
- Similarity with cemented total hip arthroplasty (THA) system
  - Cemented femoral component with varying size of neck.
- Advantages:
  - One can preserve his normal acetabulum for long time.
  - Option for THA is open (only acetabular component is needed).
  - Increase overall longevity of implant.

TOTAL HIP ARTHROPLASTY IMPLANT (FIGS 27.3A AND B)

- *Component of total hip arthroplasty (THR) system:*
  - Acetabular shell
  - Acetabular liner

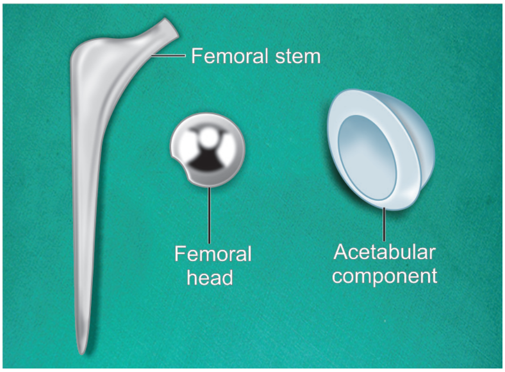


Fig. 27.3A Total hip arthroplasty implant (cemented)

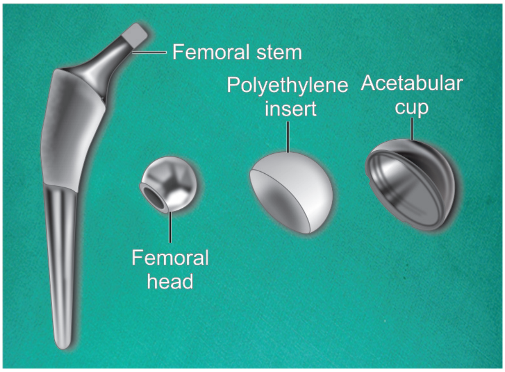


Fig. 27.3B Total hip arthroplasty implant (uncemented)

   – Head
   – Femoral stem.
- *Bearing surfaces in hip arthroplasty:* Hard on soft (metal on polyethylene and ceramic on polyethylene) and hard on hard (metal on metal, ceramic on ceramic, and ceramic on metal.
   – *Metal on poly:* Here head is made up of cobalt-chromium alloy and cup is constituted by ultrahigh molecular weight polyethylene. It provides greater range of motion and minimal impingement. The aseptic autolysis produced by polyethylene wear particles can be minimized by use of highly cross- linked polyethylene.
   – *Ceramic on poly:* Here head is made up of alumina or zirconia and cup is constituted by polyethylene. The polished surface ensures minimal friction and better joint lubrication. The aseptic autolysis produced by polyethylene wear particles can be minimized by use of highly cross-linked polyethylene.
   – *Metal on metal:* Here both head and cup were made up of metal. As head size were larger hence they could provide greater range of motion and minimal impingement. Some serious limitations with these bearing surfaces were as:
      ◆ Oncogenic nature of cobaltions.
      ◆ ALVAL (aseptic lymphocytic vasculitis associated lesion.
      ◆ Truniosis wearing at head and neck interface.
   – *Ceramic on ceramic:* Here both head and cup are made up of ceramics. Although the biocompatibility of ceramic is advantageous as bearing surfaces but some limitations are:
      ◆ Continuous squeaking sound.
      ◆ Chipping.
      ◆ Stripe wear at edges.
      ◆ Fracture.
   – *Ceramic on metal:* Here head is made up of ceramic but cup is metallic. The major advantages are:
      ◆ Increased option of femoral head size.
      ◆ Larger head size leading to minimal chance of fracture.
      ◆ Less wear and tear and minimal production of metallic particles.
- *Femoral stem in hip arthroplasty:* Cemented stem and cementless stem
   – Cemented stem:
      ◆ *Two types:*
         - Roughened or textured surface design—higher rate of loosening and bone resorption.
         - Polished, tapered and collarless design—no bonding between cement and metal interface.
      ◆ Cement mantle around femoral stem is 2–5 mm.
      ◆ Ratio of femoral stem and cement mantle in femoral canal is 2:1.

- The ideal length of cement mantle distal to tip of stem is 2–3 cm.
- *Cementless stem:*
  - On basis of mechanism of fixation:
    - Press fit.
    - Porous coated-coating of hydroxyapatite and cobalt-chromium alloy and pore size ranging from 50 µ to 400 µ.
  - *On the basis extent of coating of stem:*
    - Proximally coating.
    - Extensive coating-where proximal bone loss is severe.
  - *Part of implant going to fix first:*
    - Metaphyseal fit—preferred.
    - Diaphyseal fit—metaphyseal bone loss due to stress shielding.
  - *Geometry of stem:*
    - Straight stem-most common.
    - Anatomical stem-having proximal posterior bowing with distal anterior bowing-used commonly in revision cases.
- *Tribiology:* It deals with study of friction, lubrication and wear between the two surfaces which are continuous in motion. There are four types of wear:
  1. Abrasive wear—loss of material due to continuous rubbing of two uneven surfaces.
  2. Adhesive wear—transfer of a film of material from one surface to another.
  3. Third body wear—a foreign body like bone cement or bone particle accelerate the process of wearing between two adjoining surfaces.
  4. Fatigue wear—due to repeated loading there is minute fracture from articulating surfaces.

TOTAL KNEE ARTHROPLASTY SYSTEM (FIG. 27.4)

- *Component of total knee arthroplasty (TKA) system:*
  - Femoral component.
  - Tibial component.
  - Insert.
- *Types of TKA system*
  - Fixed bearing-insert is fixed with tibial component.
  - Mobile bearing-insert is not fixed with tibial component.

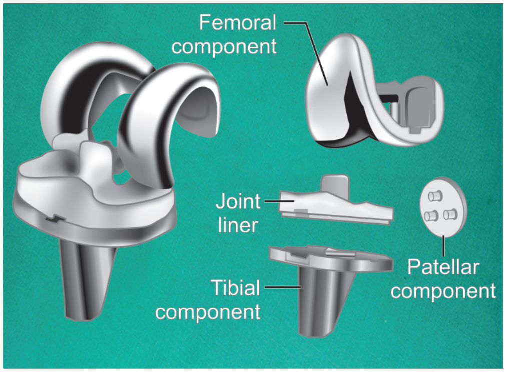


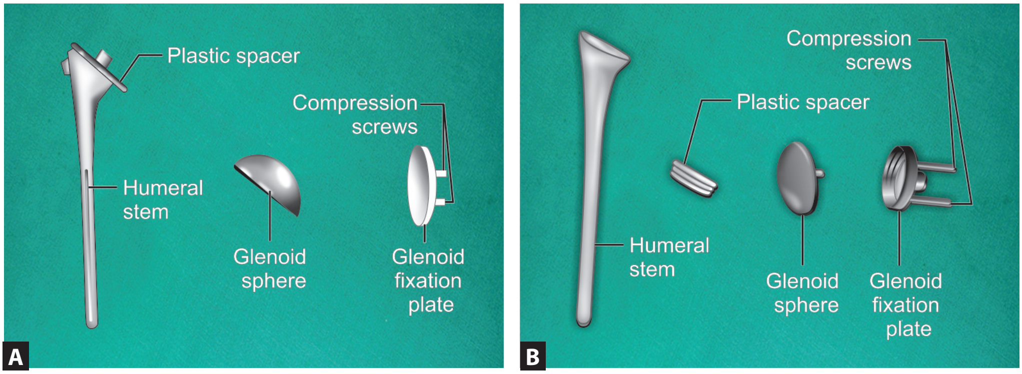
Fig. 27.4 Total knee arthroplasty (TKA) system

Fig. 27.5 Neer's shoulder prosthesis

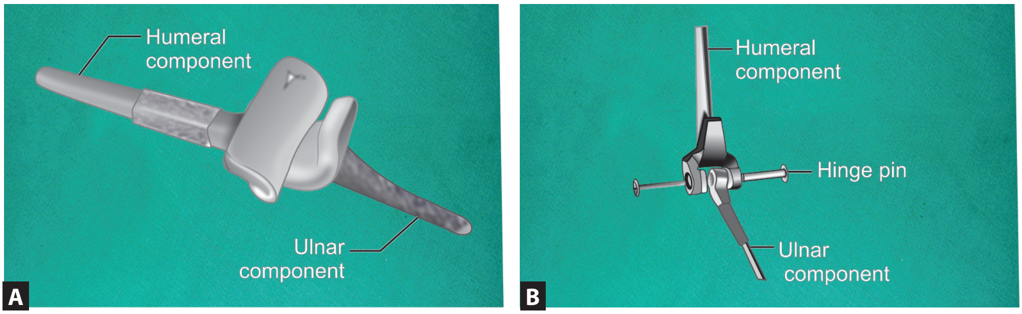
NEER'S SHOULDER PROSTHESIS (FIG. 27.5)

Parts of prosthesis:

- Humeral head.
- Stem.



Figs 27.6A and B Total shoulder arthroplasty (TSA) system. (A) Conventional; (B) Reverse



Figs 27.7A and B Total elbow arthroplasty (TEA) system. (A) Unconstrained; (B) Semiconstrained

TOTAL SHOULDER ARTHROPLASTY SYSTEM (FIGS 27.6A AND B)

- *Components conventional total shoulder arthroplasty (TSA) system:*
  - Glenoid component.
  - Humeral head.
  - Stem.
- *Components reverse TSA system:*
  - Glenoid fixation device (base plate) with compression screw:
    - Glenoid sphere.
    - Plastic spacer.
    - Humeral stem.

TOTAL ELBOW ARTHROPLASTY SYSTEM (FIGS 27.7A AND B)

- *Components of unconstrained total elbow arthroplasty (TEA) system:*
  - Humeral component.
  - Ulnar component.
- *Components of semiconstrained TEA system:*
  - Humeral component.
  - Bearing with hinge pin.
  - Ulnar component.

CHAPTER

28

Special Implants for Arthrodesis

CHARNLEY'S CLAMP (FIG. 28.1)

- *Components:*
  - Telescopic rods
  - Two clamp at ends of rod
  - A winged nut
- *Charnley's compression system consists of:*
  - Two Steinmann pin
  - Two Charnley's clamp
- Commonly used for knee, ankle and elbow arthrodesis.

COBRA PLATE FOR HIP ARTHRODESIS (FIG. 28.2)

- *Parts of plate:*
  - Proximal end—just like hood of snake cobra
  - A bend to accommodate the step between greater trochanter and pelvis
  - Stem for femoral shaft
- *Two types of screw:*
  1. 6.5 mm cancellous screw for proximal end going into head and pelvis.
  2. 4.5 mm cortical screw for femoral shaft.

LONG INTERLOCKING NAILS (FIG. 28.3)

- These are specially designed to interlocking nails with a curvature that accommodate both anterior bowing of femur and knee valgus.
- Nail length determination from greater trochanter to 2–6 cm above tibial plafond.

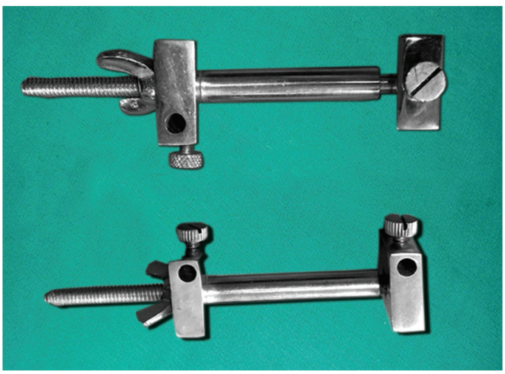


Fig. 28.1 Charnley's clamp

Fig. 28.2 Cobra plate for hip arthrodesis

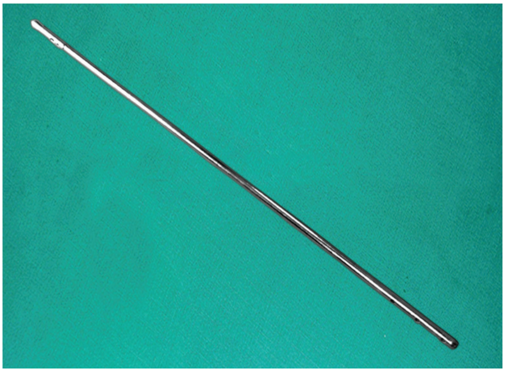


Fig. 28.3 Long interlocking nails

- *Commonly used nails are:*
  - Nail diameter—11, 12, 13 mm
  - Nail length—50, 55, 60, 65, 70, 75 cm
- Used for knee arthrodesis.

OTHER IMPLANTS USED FOR ARTHRODESIS

- Reconstruction plates
- Dynamic compression plates
- Screw (cortical and cancellous)
- External fixators
- Calandruccio-clamp
- Proximal femoral nail
- Blount's staples
- Combination of above implants.

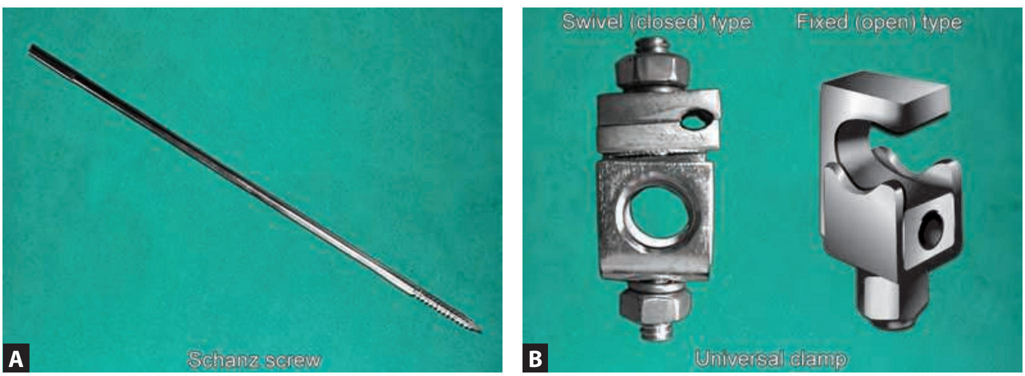
CHAPTER

29

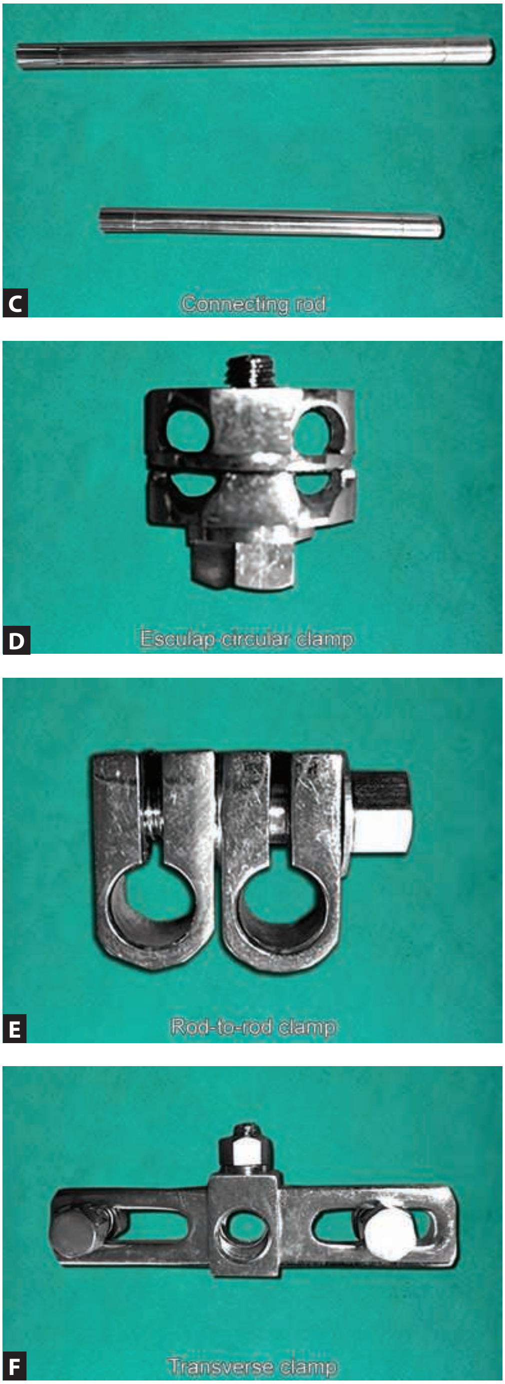
Some Implants for External Fixators

COMPONENTS OF AO EXTERNAL FIXATOR FRAME: (ME MULLER-1952) (FIGS 29.1A TO F)

- *Schanz screw: parts:*
  - Tip—make a drill hole before inserting it
  - Thread—threaded portion engages in far cortex of bone
  - Shaft—shaft engages in near cortex of bone
  - Top—quadrangular top firmly holded by T-handle.
- *Sizes:* Diameter 2–6 mm at interval of 0.5 mm
  - Femur, tibia and humerus—4.5 mm, 5.0 mm and 5.5 mm
  - Radius and ulna—3.5 mm
  - Metacarpal and metatarsals—2.5 mm.
- *Clamp:*
  - *Universal clamp:*
    - Swivel/closed type
    - Fixed/open type
  - Esculap circular clamp
- *Central body or connecting rod:* (AO type: 11 mm diameter, 10 cm–60 cm length)
- *Coupling:* Rod to rod clamp
- *AO transverse clamp:* For example, in proximal tibial compound fractures where proximal fragment is smaller.



Figs 29.1A and B Components of AO external fixator frame



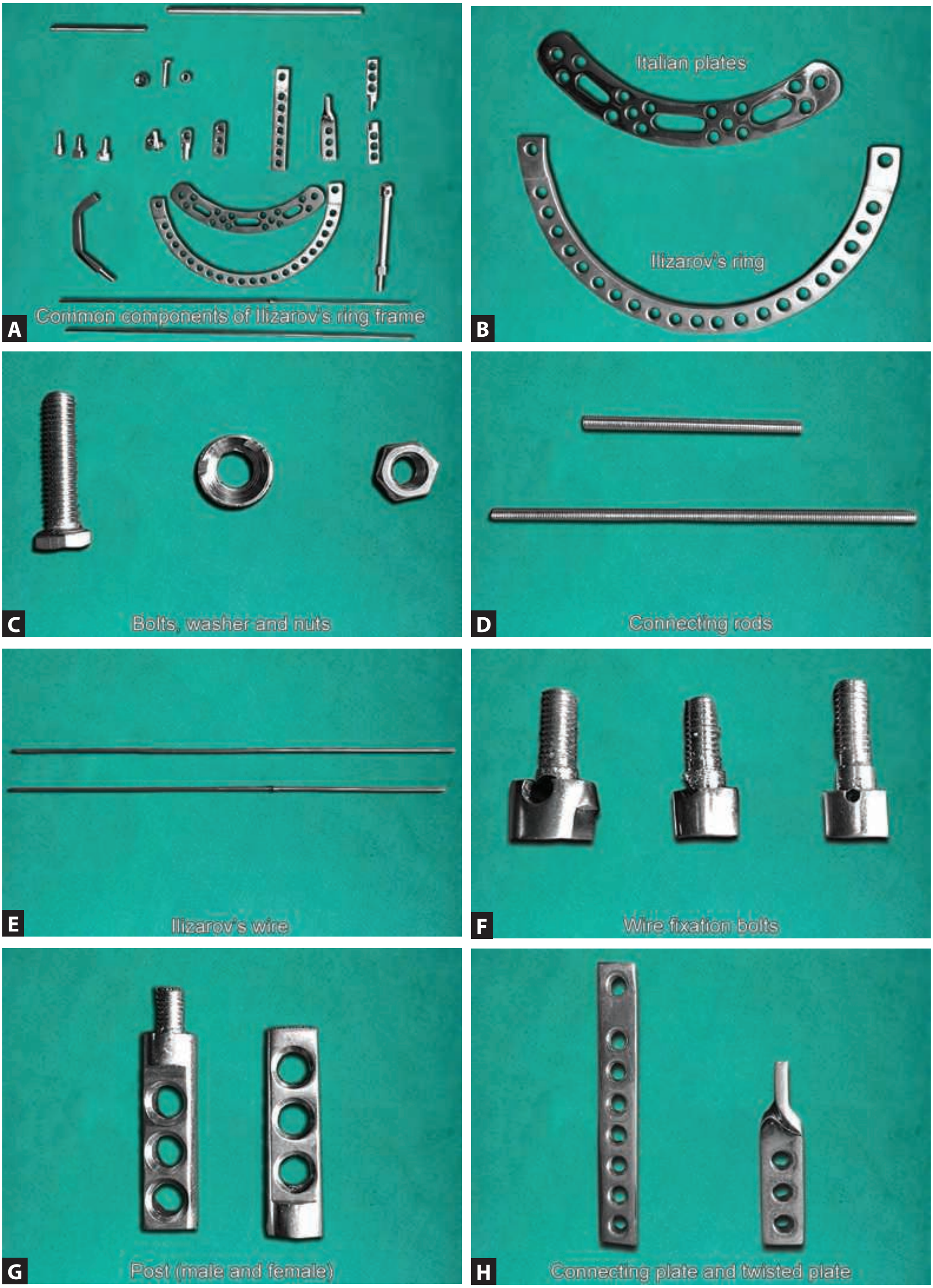
Figs 29.1C to F Components of AO external fixator frame: (ME Muller–1952)

COMPONENTS OF ILIZAROV'S RING FRAME AND JESS FIXATOR (FIGS 29.2A TO J)

- *Rings:* Semicircular half ring
  - Made up of stainless steel and epoxy resin reinforced with carbon fibers.
  - *Internal diameter range:* 80 to 240 mm (12 types)
    - for children (80 mm, 100 mm, 110 mm, 120 mm, 130 mm, 140 mm)
    - for adult (150 mm, 160 mm, 180 mm, 200 mm, 220 mm, 240 mm)
  - *Number of holes per ring:* 18–28
  - *Hole diameter:* 8 mm; each hole 4 mm apart.
- *Arches (Italian plates):* 90° and 120°
- *Bolts and nuts:*
  - *Bolts:* Head diameter 10 mm, shaft diameter 6 mm, pitch 1 mm
  - *Nuts:* Diameter 6 mm, height 6 mm, 5 mm and 4 mm
- *Connecting rods:* Diameter 6 mm, length 6–40 cm
- *Wires:* Plain and olive
  - For children 1.5 mm diameter wire and for adult 1.8 mm diameter wire
  - Bayonet tip for cortical bone and trocar tip for cancellous bone.
- *Wire fixation bolts:*
  - Cannulated with 2 mm hole
  - Slotted
- *Washers:* Internal diameter 7 mm, thickness 1.5–4 mm
- *Other component:*
  - Rancho (threaded socket) and bushing
  - Post (male and female)
  - Twisted plates (straight or curved)
  - Connecting plates
  - Hinges (male and female)
  - Distractors, etc.

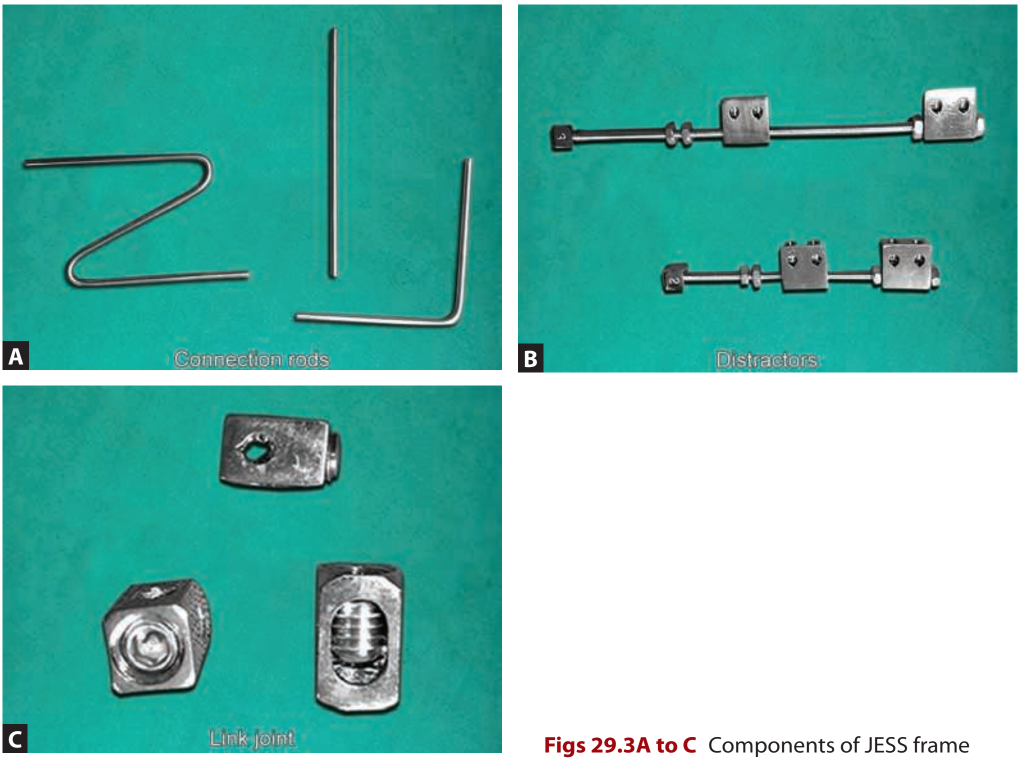
COMPONENTS OF JESS FRAME (FIGS 29.3A TO C)

- *Connecting rods:* Straight, L and Z shaped
- Distractors
- *Link joint:* α, β clamps
- *K-wires:* 1.2 mm, 1.5 mm, 2 mm diameter of 15–20 mm length



Figs 29.2A to H

Figs 29.2A to J Components of Ilizarov's ring frame



Figs 29.3A to C Components of JESS frame

CHAPTER

30

Miscellaneous Materials

SUTURE MATERIALS, NEEDLES AND KNOTS (FIGS 30.1A AND B)

- *Suture:* Any thread or strand which brings two surfaces/tissues into apposition is known as suture. These may be absorbable or nonabsorbable.
- *Ligature:* Any thread/strand which obliterates lumen of ductular structures is known as ligature.
- *Ideal suture characteristics:*
  - Uniform diameter
  - Nonallergic
  - Noncarcinogenic
  - Adequate tensile strength
  - Easily sterilized
  - Minimal tissue reaction
  - Easily available
  - Less expensive.

Fig. 30.1A Suture materials (absorbable)

Fig. 30.1B Suture materials (nonabsorbable)

Absorbable and nonabsorbable suture materials			
Suture name	*Color*	*Composition*	*Absorption time*
Absorbable suture materials:			
Plain catgut	Yellow	Serosa and submucosa of sheep intestine	80 days
Chromic catgut*	Tan (Brown)	Plain catgut + 20% chromate + glycine	100 days
Vicryl	Violet	Polyglactin	80 days
Dexon	Violet/green	Polyglycolic acid	100 days
Poly-diaxones (PDS)	White	Polyester-polymer	100 days
Nonabsorbable suture materials:			
Suture name	*Color*		*Source*
Cotton	White		Cotton fibers
Silk	Black		Silk worm
Prolene	Blue		Polypropylene
Nylon/ethilon	Black/green		Monofilament polyamide
Ethibond	Green		Polyester ethylene terephthalate
* chromium increases knot holding time			

- *Monofilament vs polyfilaments:*

Points	*Monofilament*	*Polyfilament*
Organism penetrance	Not possible	Possible
Chances of infection	Low	High
Slippage of knot	Likely to slip	Knot secured
Example	Prolene, nylon	Silk, vicryl

- *Methods of suturing:*
  - Continuous suturing
  - Interrupted suturing (simple and mattress)
  - Subcuticular suturing.
- *Common types of knots:* (Fig. 30.2)
  - Square (reef) knot—most commonly used
  - Granny knot—liable to slip
  - Surgeon's knot—never slip.
- *Surgical needles: (Figs 30.3A to C)*
  - *Parts of needle:*
    - Tip
    - Body
    - Eye
  - *Classification of needle on the basis of eye:*
    - Eye needle—traumatic
    - Eyeless needle—atraumatic
  - *Classification of needle on the basis of tip:*
    - Round body needle
    - Taper cut needle
    - Reverse cutting needle
  - *Classification of needle on the curvature of needle:*
    - Straight needle
    - 3/8 Circle
    - 1/2 Circle
    - 5/8 Circle

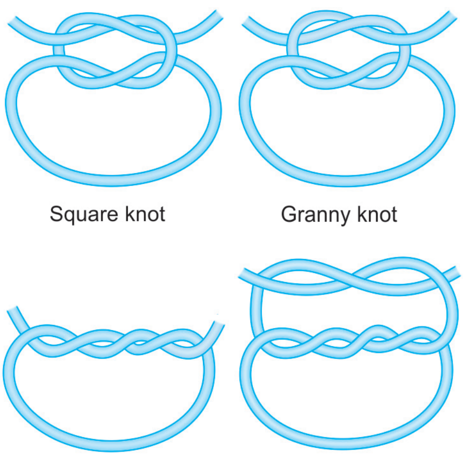


Fig. 30.2 Common types of knots

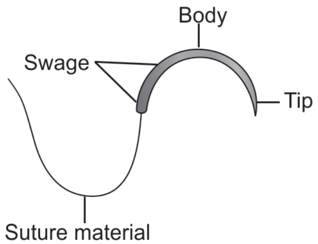


Fig. 30.3A Parts of surgical needle

Needle point types and their symbols

Point type	**Symbol**
Taper point	●
Blunt taper point	○
Cutting edge	▲
Reverse cutting edge	▼
Tapercut	☮

Fig. 30.3B Tips of surgical needles

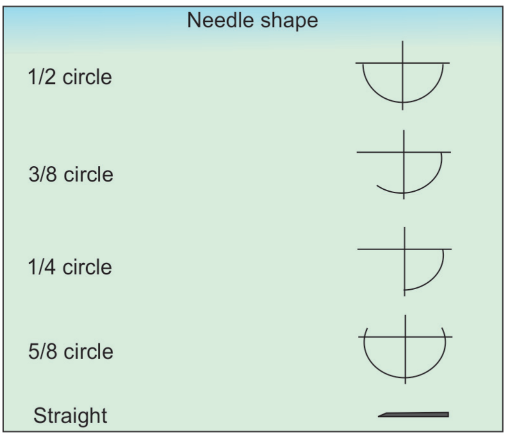


Fig. 30.3C Different curvature of surgical needles

BONE CEMENT (FIG. 30.4)

Fig. 30.4 Bone cement and liquid

- *Composition:*
  - *Polymer powder:*
    - PMMA (polymethyl methacrylate)
    - Benzoyl peroxide—initiator
    - Barium sulfate —radiopaque
    - Ascorbic acid—stabilizer.
  - *Monomer liquid:*
    - Methyl methacrylate
    - DMP-toluidine—activator.
- *Phases of mixing of cement:*
  - *Dough time:* Last till cement does not stick to surgical gloves (2–3 minutes)
  - *Working time:* Cement is so tough to manipulate (5–8 minutes)
  - *Setting time:* Dough time + working time (8–10 minutes).
- *Method to increase working time:*
  - Slow mixing speed
  - Decrease temperature of cement
  - Decrease humidity of operation theater (OT) environment
  - Large cement particle size.
- *Viscosity of cement:*
  - as per Stryker
    - Simplex P cement-stryker; desirable viscosity can be obtained, commonly used in medium viscosity
    - Placos cement—high viscosity
  - as per Depuy
    - CMW-1: standard viscosity
    - CMW-2: standard viscosity but fast setting
    - CMW-3: low viscosity cement
- *Generation of cement:*

1st generation	*2nd generation*	*3rd generation*
Finger packing	Usage of cement gun	Vacuum mixing with centrifugation
No canal preparation	Pulsatile lavage	Pressurization of cement
No cement plug	Canal preparation	Stem centralizer
No pressurization	Cement restrictor	

- *Terminologies related to bone cement:*
  - *Pre-cooling:* Decreases number of pores in cement
  - *Vacuum mixing:* Increases bending strength (15–30%)
  - *Centrifugation:* Increases fatigue strength (9%).
- *Uses of cement:*
  - Arthroplasty
  - Kyphoplasty
  - Vertebroplasty
  - As spacer after removal of infected prosthesis
  - For augmentation of screw in osteoporotic fracture
  - For making antibiotic delivery system, e.g. cement beads.
- *Contraindication of cement use:*
  - Cement hypersensitivity
  - Acute infection at the site of use.
- *Antibiotic impregnated bone cement:*
  - *Characteristics of antibiotic:*
    - Thermostable
    - Water soluble
    - Bactericidal
    - Minimum allergic property
    - Antibiotic property not affected by temperature
    - Rare or no development of resistance against antibiotic
    - Gradual release of antibiotic from cement.

- *Dosing of antibiotic:*
  - *Low dose:* Less than 2 g of antibiotic/40 g of cement, used for THR and TKR surgeries as prophylaxis.
  - *High dose:* More than 2 g of antibiotic/40 g of cement, used in revision THR, spacers, beads formation.
- *Elution of antibiotic from bone cement:*
  - By bulk surface diffusion mechanism
  - Rapid phase (1–7 days)
  - Stationary phase (4–6 weeks).
- *Factors affecting elution of antibiotics:*
  - Surface roughness
  - Porosity
  - Concentration of antibiotics.
- *Availability of antibiotic to local tissue:* 10% of total antibiotics.

SECTION 3

Table of Orthopedic Radiographs

Upendra Kumar

Chapters

STUDY OF RADIOGRAPHS

- Reading of radiographs is an art, it can be developed only after a repeated practice.
- *Read the radiograph as follows:*
  - Say in single sentence, as this is—
    - Plain/contrast radiograph
    - *Region:* For example, pelvis
    - *View:* For example, anteroposterior/lateral
    - Skeletally mature/immature
    - Showing bones, for example in knee X-ray. Distal femur, patella, upper tibia and fibula
    - Comments on local findings:
      - *Soft tissue:* For example, appears to be normal
      - Bone or joint findings
      - Also comment on some special lines, angles, etc.

CHAPTER

31

Radiographs of Fracture

PRELIMINARY KNOWLEDGE FOR STUDY OF FRACTURE X-RAY

- *Body parts involvement:* Bone identification
  - Axial skeleton
  - Appendicular skeleton.
- *Clinical anatomy of bone:*
  - For example, parts of radius—head, neck, shaft, distal end
    - Radial height = 12 mm
    - Volar tilt = 11°
    - Radial inclination = 22°.
- *Parts of bone:*
  - Epiphysis
  - Metaphysis
  - Diaphysis.
- *Mechanism of injury:*
  - Fall from height, road traffic accident, ballistics
  - Forces acting on bone-bending, shear, impaction, torsional
  - Energy of trauma—high energy, low energy.
- *Fracture pattern:*
  - Transverse fracture
  - Oblique fracture
  - Butterfly pattern
  - Spiral fracture
  - Comminuted fracture
  - Segmental fracture.
- *Joint involvement:*
  - Extra-articular
  - Intra-articular.
- *Displacement of fracture fragment:*
  - Undisplaced
  - Displaced.
- *Factors of fracture stability:*
  - For example—for intertrochanteric fracture
    - Posteromedial comminution (lesser trochanter)
    - Reverse obliquity
    - Subtrochanteric extension.
- *Neurovascular status:*
  - For example, radial nerve involvement in Holstein-Lewis fracture of humerus
  - Brachial artery involvement in supracondylar fracture of humerus.
- *Fracture communication with exterior:*
  - Closed fracture
  - Compound fracture.

X-RAY: ETIOLOGICAL CLASSIFICATION OF FRACTURE (FIGS 31.1A TO C)

Etiological classification of fracture:

- *Traumatic fracture:*
  - History of trauma
  - Variable energy of trauma
  - Variable displacement
  - Various pattern.
- *Pathological fracture:*
  - Some pathological etiology like tumor, osteoporosis present
  - Produced by trivial trauma

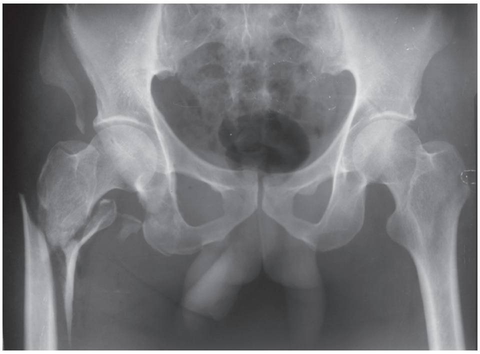


Fig. 31.1A X-ray: Traumatic fracture
(*Courtesy:* Dr Tarun solanki)

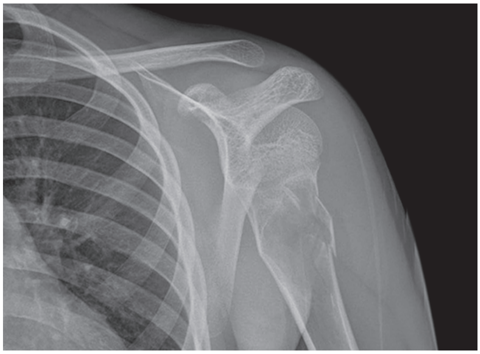


Fig. 31.1B X-ray: Pathological fracture
(*Courtesy:* Dr Anurag sharma)

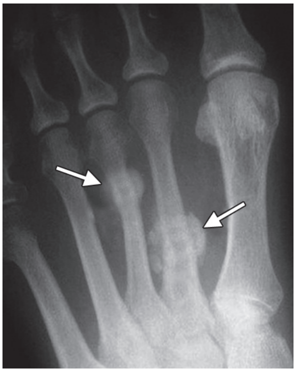


Fig. 31.1C X-ray: Stress fracture

- Minimal displacement
- Transverse fracture pattern is the most common.

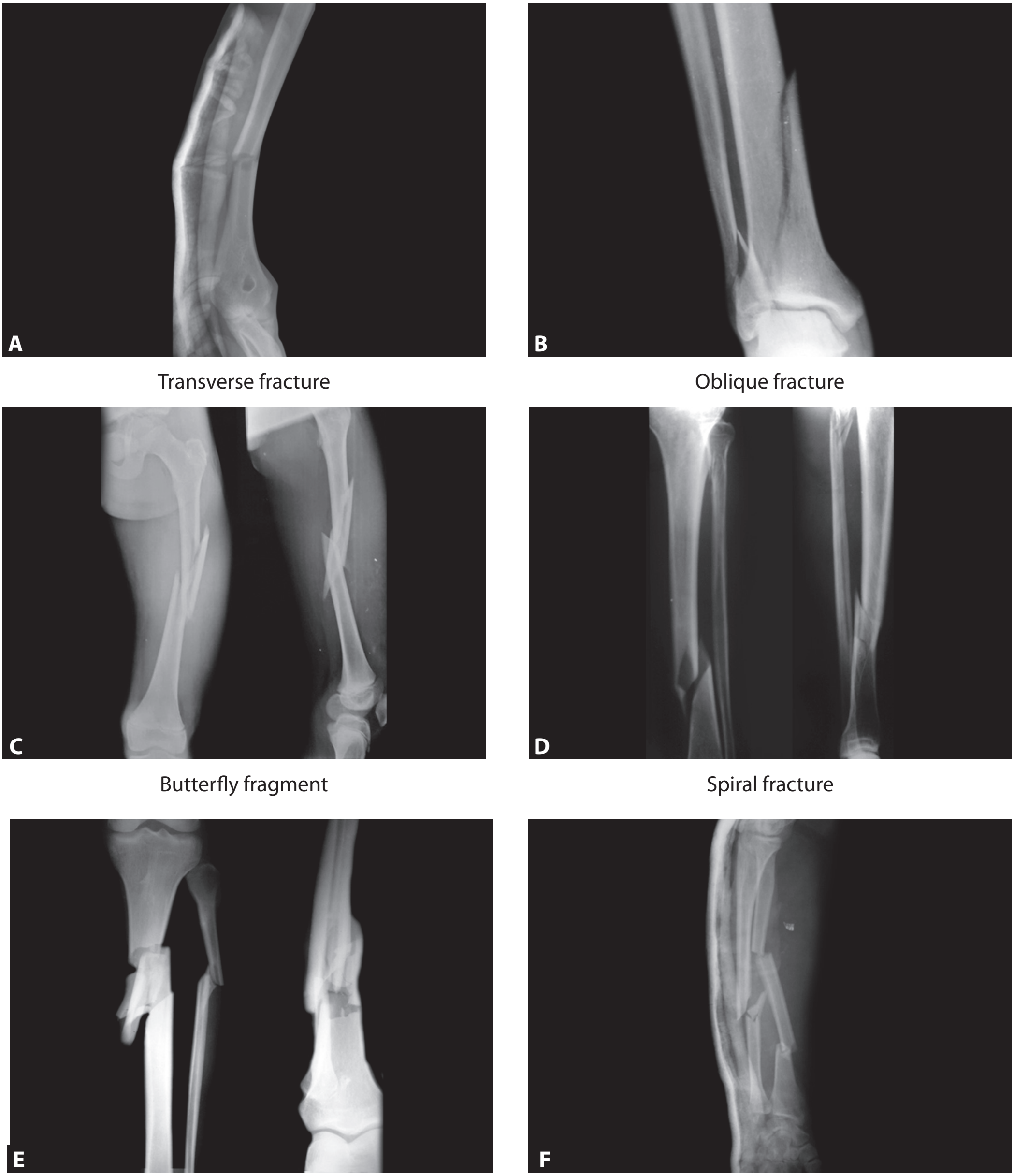
- *Stress fracture:*
  - Repetitive stress in professional like dancers, athlete, military persons
  - Zone of callus formation visible
  - Faint hairline undisplaced fracture
  - Transverse fracture pattern
  - Bone-scan is diagnostic
  - Common sites are metatarsals (shaft of 2nd most common), tibia, fibula.

X-RAY: FRACTURE PATTERNS AND MECHANISM OF INJURY (FIGS 31.2A TO F)

- *Various patterns of fracture:*
  - Transverse fracture
  - Oblique fracture
  - Spiral fracture
  - Comminuted fracture
  - Butterfly fragment
  - Segmental fracture.

Comparisons of various fracture patterns and mechanism of injury

Fracture patterns	*Fractures line*	*Loading forces*	*Energy of trauma*
Transverse fracture	Makes an angle less than 30° with a line perpendicular to long-axis of bone	Bending force	Low energy
Oblique fracture	Makes an angle more than 30° with a line perpendicular to long-axis of bone	Bending and compression forces	Moderate energy
Butterfly	A broad triangular fracture fragment present in diaphyseal comminuted fracture	Bending and compression forces	Moderate energy
Spiral fracture	Three dimensional	Torsional forces	Low energy
Comminuted fracture	Multiple small fragments at fracture site	Variable torsion	High energy
Segmental fracture	More than two fracture fragments	Impact at more than one site	High energy



A Transverse fracture

B Oblique fracture

C Butterfly fragment

D Spiral fracture

E Comminuted fracture

F Segmental fracture

Figs 31.2A to F X-ray: Various fracture patterns
(*Courtesy:* Dr Tarun solanki)

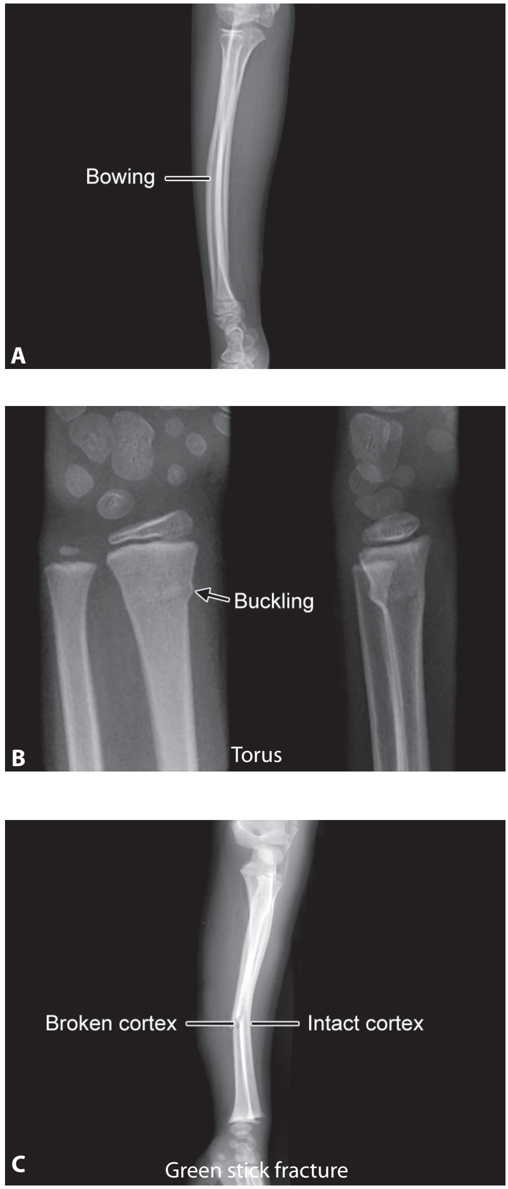
X-RAY: PEDIATRIC FRACTURE

- *Characteristics of pediatric fracture:*
  - Due to great elasticity and thick periosteum, incomplete fractures are common.
  - Due to weak physeal zone avulsions are more common.
  - Due to high growth potency fracture healing is faster.
  - Maximum remodeling capacity around fracture.
  - Minimal periarticular stiffness.
- *Pediatric fracture classification (Figs 31.3A to C):*
  - *Bowing:* Here only plastic deformation of bone
  - *Torus:* Only buckling of cortex
  - *Green stick fracture:* Here only one cortex is broken other is intact
  - *Epiphyseal fracture (Fig. 31.4).*

***Salter-Harris** classifications of pediatric fracture:*

- *Type I:* Transverse fracture running through the physis.
- *Type II:* The most common pattern of epiphyseal injury where fracture line run the through the physis and the metaphysis, producing a beak like corner. **Thurston Holland** sign or shiny corner sign.
- *Type III:* Fracture line running through physis and epiphysis.
- *Type IV:* Here fracture line passes through the physis, metaphysis and epiphysis.
- *Type V:* It is a compression fracture of the physis.
- *Type VI:* It is an injury of peripheral portion of the physis **(Mercer Rang-1969)**.

- *Treatment options:*
  - Closed reduction and immobilization.
  - Closed reduction and percutaneous fixation (K-wire or screw).
  - Open reduction and fixation.



Figs 31.3A to C X-ray: Pediatric fracture (*Courtesy:* Dr Govind Ballav Joshi)

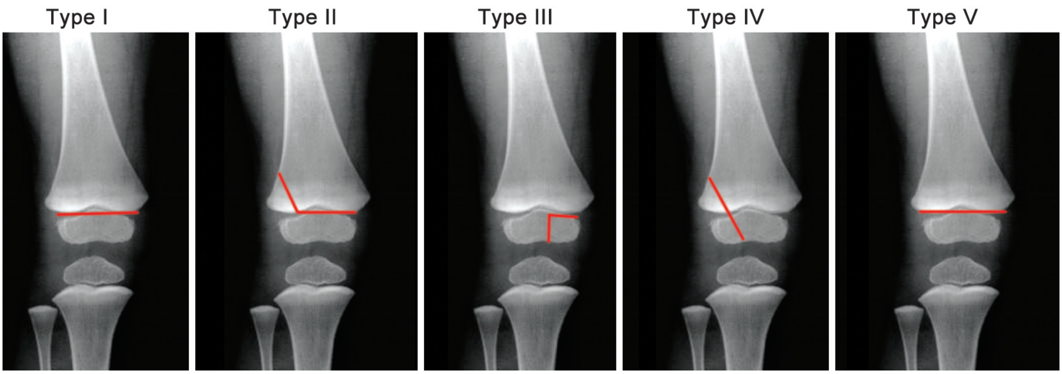
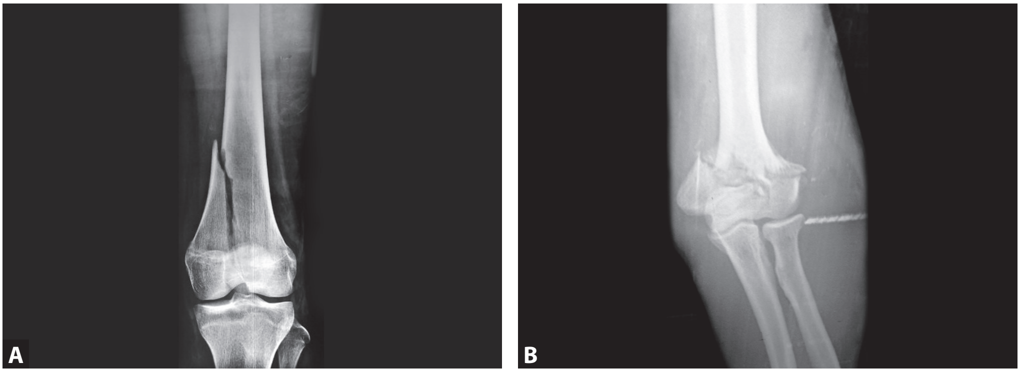


Fig. 31.4 Salter-Harris classifications



Figs 31.5A and B X-rays: periarticular fractures. (A) Distal femur; (B) Distal humerus (*Courtesy:* Dr Tarun solanki)

X-RAYS: PERIARTICULAR FRACTURES (FIGS 31.5A AND B)

- *Characteristics of intra-articular fracture:*
  - Atleast one fracture line enter into the joint
  - Minimal or no step is acceptable
  - Prone for stiffness hence early mobilization essential
  - Prone to produce early degenerative changes
  - Functional disability possible.
- *Muller's classification of periarticular fracture (e.g. distal femur):*

- *Type A—extra-articular fracture*
  A1—simple
  A2—metaphyseal wedge
  A3—metaphyseal complex.
- *Type B—partial articular fracture*
  B1—lateral condyle, sagittal plane
  B2—medial condyle, sagittal plane
  B3—frontal plane.
- *Type C—Intra-articular fracture*
  C1—articular simple, metaphyseal simple
  C2—articular simple, metaphyseal complex
  C3—multifragmentary articular fracture.

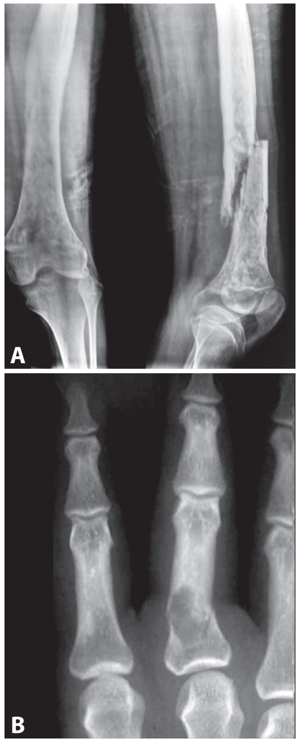
- *Treatment options:*
  - Closed reduction and immobilization
  - Closed reduction and percutaneous fixation with implant
  - Open reduction and fixation with implant.

X-RAY: PATHOLOGICAL FRACTURES (FIGS 31.6A AND B)

- *Etiological classification of pathological fracture:*
  - *Infective disorder:*
    - Chronic pyogenic osteomyelitis
    - Chronic tubercular osteomyelitis.
  - *Tumorus disorder:*
    - Cystic lesion like simple bone cyst, ABC
    - Malignant tumor, e.g. osteosarcoma, chondrosarcoma, multiple myeloma.
  - *Metabolic disorder:* Osteoporosis, hyperparathyroidism
  - *Genetic and dysplastic disorder.*
    - Fibrous dysplasia
    - Osteogenesis imperfecta, osteopetrosis.

Mirel's criteria for risk of pathological fracture			
	Number given 1	*Number given 2*	*Number given 3*
Site	Upper arm	Lower extremity	Peritrochanteric
Pain	Mild	Moderate	Severe
Lesion	Blastic	Mixed	Lytic
Size	<1/3 diameter of bone	1/3–2/3 diameter of bone	>2/3 diameter of bone
Total score 8 or more for a patient prophylactic fixation is done.			

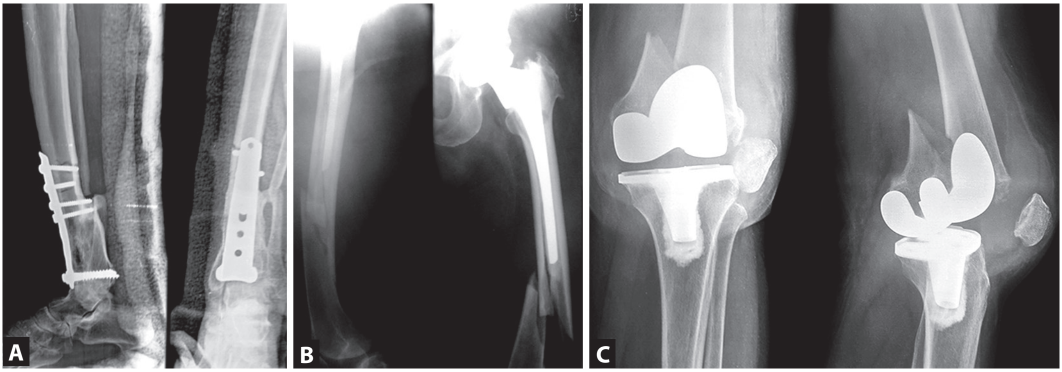
- *Treatment options:*
  - Treatment of underlying pathology
  - Improvement of bone stock
  - Prophylactic or definitive fixation of pathological bone.



Figs 31.6A and B X-ray: pathological fractures. (A) Chronic osteomyelitis; (B) Tumor (*Courtesy:* Dr DK Taneja)

X-RAY: PERI-IMPLANT FRACTURE (FIGS 31.7A TO C)

- *Risk factors for peri-implant fracture:*
  - Underlying bone disease like osteoporosis, inflammatory disorder, etc
  - Revision surgeries, e.g. total hip replacement or total knee replacement (THR or TKR)
  - Inadequate bone preparation for implant, e.g. tight femoral canal
  - Improper fitting of implant or implant in stress, e.g. notching of femoral component in TKR
  - Premature weight bearing, e.g. in nailing or plating.
- *Peri-implant fracture may be of two types:*



Figs 31.7A to C X-ray: Peri-implant fracture
(*Courtesy:* Dr Anand Shankar)

1. Peroperative—during surgical procedure
2. Postoperative—in any other period.

- *Classification of periprosthetic fractures:*

Periprosthetic fracture around hip (Vancouver classification)
• *Type A—trochanteric*
A_L —around lesser trochanter
A_L —around greater trochanter
• *Type B—around or distal to stem*
B_1—well fixed stem
B_2—loose stem
B_3—loose stem with poor quality bone
• *Type C—distal to stem—well fixed stem*

Periprosthetic fracture around knee
Rorabeck, **Angliss** *and* **Lewis** classification of femoral fracture:
Type I—prosthesis stable with undisplaced fracture
Type II—prosthesis stable with displaced fracture
Type III—prosthesis unstable with or without fracture displacement
Felix, **Stuart** and **Hansen** classification of tibial fracture:
• Type I—plateau fracture
• Type II—fracture adjacent to stem
• Type III—fracture distal to stem
• Type IV—tibial tuberosity fracture.

- *Treatment options:*
  - Reduction of fracture fragment and stable fixation with:
    - Stainless steel wire
    - Long metaphyseal plating
    - Bone graft or bone cement augmentation
    - Revision arthroplasty with long stem component
    - Combination of implant.
  - Bone stock augmentation.

CHAPTER

32

Radiographs of Tumor

DESCRIPTION OF A TUMOR RADIOGRAPHS (FIG. 32.1)

- *Tumor location:*
  - Epiphyseal
  - Diaphyseal
  - Metaphyseal
- *Destruction pattern:*
  - *Geographical*—well demarcated lesion, easily differentiated from normal bone
  - Moth-eaten—multiple scattered holes in apparently normal bone.
  - Permeative—poorly demarcated lesion, not distinguishable from adjacent normal bone.
- *Margin of tumor:*
  - Well defined
  - Ill-defined
- *Corticomedullary delineation:*
  - Intact
  - Absent
- *Status of cortex:*
  - Intact
  - Breached
- *Matrix:*
  - Homogeneous
  - Heterogeneous +/– speckled calcification
- *Zone of transition:*
  - Narrow
  - Wide
  - Lost
- *Periosteal reaction:* It is a reactive new bone formation which takes one to three weeks to appear radiologically.

Various types of periosteal reaction

Broad categories	*Subtypes*	*Examples*
Solid shell periosteal reaction: When slow growing lesion erode endosteal bone which is replenished by subperiosteal bone deposition	• Smooth shells	Benign neoplasm
	• Septated ridge shells	Aneurysmal bone cyst.
Continuous periosteal reaction: Here cortex is intact	• Solid	Osteoid osteoma
	• Lamellar	Ewing sarcoma
Interrupted periosteal reaction: Here cortex is breach	• Buttress	Benign neoplasm
	• Codman triangle	Any aggressive bony reaction
Spiculated periosteal reaction: Bone formation with radial neovascularization	• Divergent spiculated appearance	Sun-burst pattern of osteosarcoma
	• Parallel speculated appearance	Hair on end appearance of Ewing sarcoma

- *Soft tissue extension:*
  - Absent
  - Present

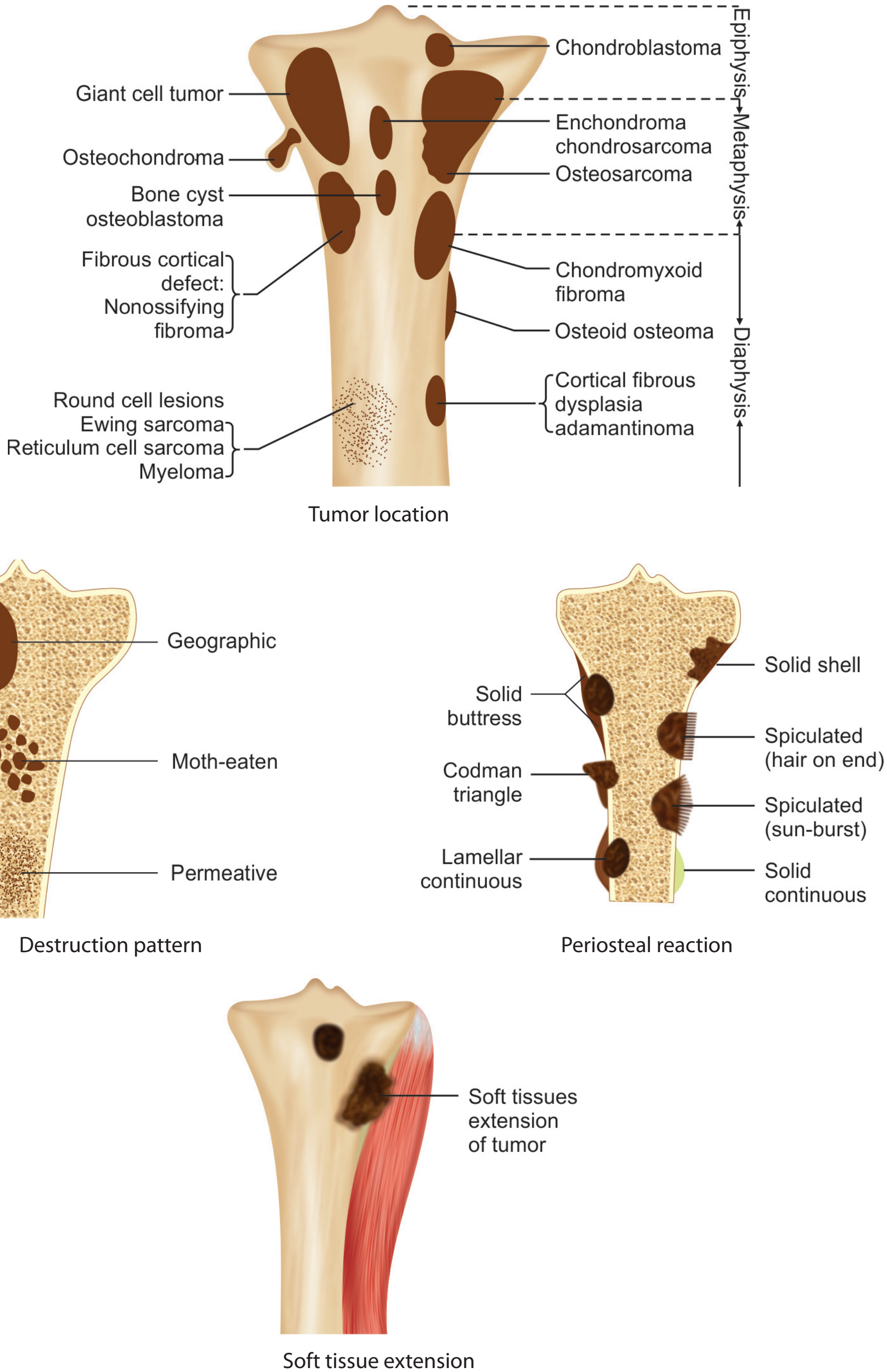


Fig. 32.1 Description of a tumor radiographs

X-RAY: OSTEOCHONDROMA (FIG. 32.2)

- *Osteochondroma:* Not a true tumor, a hamartoma, also called exostosis, arises from peripheral part of growth plate adjacent to metaphysis.
  - *Age:* 2nd decade
  - *Site:* Distal femur > proximal tibia > proximal humerus
  - Risk percentage for malignant transformation in exostosis:—chondrosarcoma
    - Solitary exostosis—1%
    - Multiple exostosis—5–6%
  - Epiphyseal site osteochondroma is called Trevor's disease.
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal outgrowth
  - *Direction of growth:* Away from the joint
  - *Stalk:* Pedunculated or sessile
  - *Margin of tumor:* Well defined
  - *Corticomedullary delineation:* Intact
  - *Cortical part of tumor:* It is continuous with cortex of parent bone
  - *Medullary cavity of tumor:* It is continuous with medullary cavity of parent bone
  - *Periosteal reaction:* Absent
  - *Soft tissue extension:* Absent

☑ *Note:* Radiological sign of malignant transformation in exostosis: chondrosarcoma.
  - Stippled calcification in cartilage cap
  - Margin of tumor becomes ill defined
  - Soft tissue extension
  - Cartilaginous cap size more than 2 cm in CT or MRI (normally thickness of cartilage cap is more in children, i.e. up to 2 cm than adult, i.e. in few millimeter.

- *Treatment options:* Extraperiosteal resection of tumor, i.e. excision of exostosis along with periosteum lying over it.

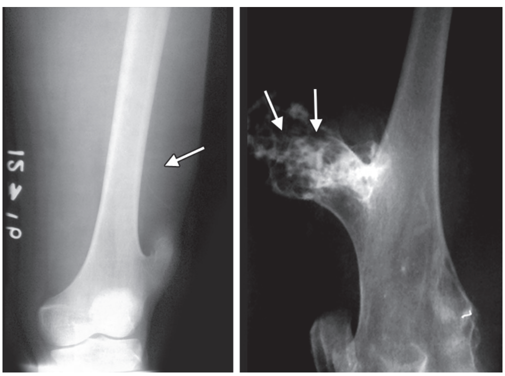


Fig. 32.2 X-ray: Osteochondroma (distal femur) (*Courtesy:* Dr DK Taneja)

X-RAY: OSTEOID OSTEOMA (FIG. 32.3)

- *Osteoid osteoma:* A bone forming tumor which be may be cortical, cancellous or subperiosteal.
  - *Age:* 2nd to 3rd decade (5–25 yr)
  - *Site:* femur > tibia > spinous process
  - Night pain is specific feature of this tumor that relieves with salicylates.
- *Description of a tumor radiographs:*
  - *Tumor location:* Diaphyseal/metaphyseal (cortical or cancellous)
  - *Destruction pattern:* Lytic, radiolucent nidus < 1.5 cm.
  - *Margin of tumor:* Well defined
  - *Corticomedullary delineation:* Intact
  - *Status of cortex:* Intact (thickened and sclerosed)
  - *Matrix:* Homogeneous
  - *Zone of transition:* Narrow
  - *Periosteal reaction:* Present (continuous-solid periosteal reaction)
  - *Soft tissue extension:* Absent

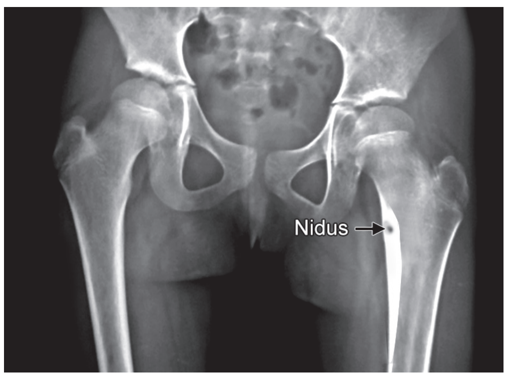


Fig. 32.3 X-ray: Osteoid osteoma (proximal femur)

☑ *Note:* If size of nidus is more than 1.5 cm, lesion is most likely osteoblastoma and CT scanning is diagnostic tool for osteoid osteoma.

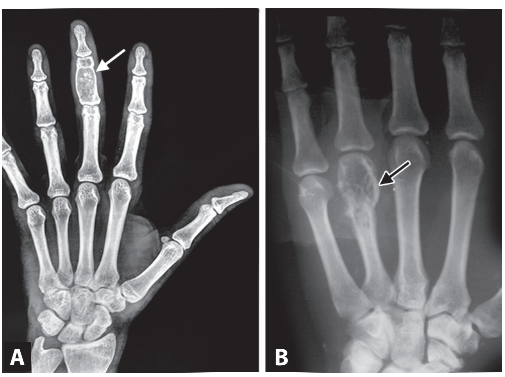
- *Treatment options:*
  - Analgesics like aspirin other NSAIDs
  - Resection of tumor mass under radiographic control
  - Power burring of nidus under radiographic control (burr down technique)
  - *Percutaneous radiofrequency ablation:* Latest treatment modality.

X-RAY: ENCHONDROMA/ CHONDROMA (FIGS 32.4A AND B)

- *Enchondroma:* A intramedullary cartilage forming tumor, sometime arises from periosteum also.
  - *Age:* Adults (3rd decade)
  - *Site:* Hand > proximal humerus > distal femur > proximal tibia
  - Risk of malignant transformation is less than 1% but it may extends up to 25–30% in Ollier' disease and Mauffici syndrome.
    - *Ollier's disease*: Multiple enchondromatosis
    - *Mauffici syndrome:* Enchondroma with hemangioma
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal
  - *Destruction pattern:* Lytic (geographical)
  - *Margin of tumor:* Well defined
  - *Corticomedullary delineation:* Lost
  - *Status of cortex:* Thinned or expanded in small bone thickened and sclerosed in others.
  - *Matrix:* Heterogeneous/central calcification from punctate to ring type
  - *Zone of transition:* Narrow
  - *Periosteal reaction:* Absent in small bone present in other (continuous-solid type)
  - *Soft tissue extension:* Absent
- *Treatment options:*
  - Asymptomatic—observation
  - If symptomatic—curettage and bone grafting.
  - If pathological fracture—first conservative, once fracture heals curettage and bone grafting.

X-RAY: SIMPLE BONE CYST (FIG. 32.5)

- *Simple bone cyst:* Also called unicameral bone cyst; cyst formation occur due to transient failure of physeal ossification.
  - *Age:* 1st to 2nd decade
  - *Site:* Proximal humerus > proximal femur > proximal tibia
  - When tumor lies nearer to physis, it is called active tumor and it migrates towards diaphysis it becomes inactive tumor.
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal/diaphyseal, centrally placed



Figs 32.4A and B X-ray: Enchondroma. (A) Phalanx; (B) Metacarpal
(*Courtesy:* Dr DK Taneja)

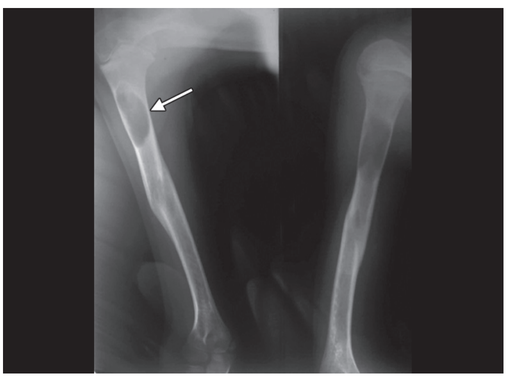


Fig. 32.5 X-ray: Simple bone cyst (proximal humerus)
(*Courtesy:* Dr John Mukhopadhyay)

- *Destruction pattern:* Lytic
- *Margin of tumor:* Well defined
- *Corticomedullary delineation:* Lost
- *Status of cortex:* Thinned out
- *Matrix:* Homogeneous
- *Zone of transition:* Narrow
- *Periosteal reaction:* Absent (present only with pathological fracture)
- *Soft tissue extension:* Absent

☑ *Note:* Fallen fragment sign in X-ray is pathognomonic feature for simple bone cyst with fracture.

- *Treatment options:*
  - *If pathological fracture:* Spontaneous resolution following conservative t/t.
  - Aspiration of cyst and intralesional injection of steroids.
  - Curettage and bone grafting.

X-RAY: ANEURYSMAL BONE CYST (FIG. 32.6)

- *Aneurysmal bone cyst:* A vasocystic tumor formed following arteriovenous malformation in metaphysis (most accepted theory).
  - *Age:* 1st to 2nd decade
  - *Site:* Proximal humerus > proximal femur >proximal tibia > spinous process
  - ABC of spinous process closely resembles osteoblastoma.
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal/diaphyseal, eccentric

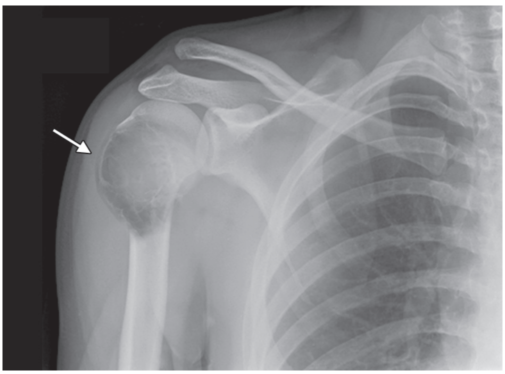
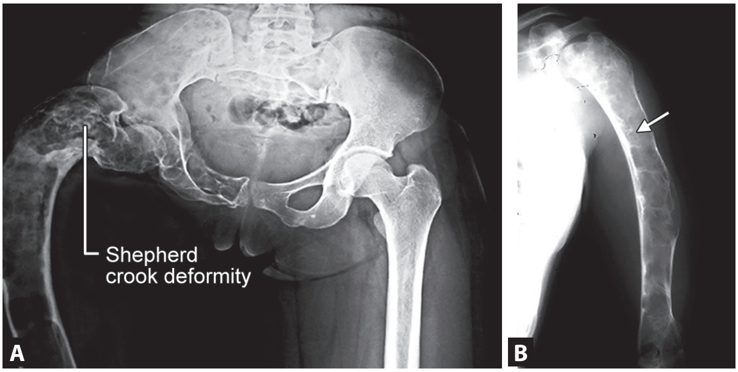


Fig. 32.6 X-ray: Aneurysmal bone cyst (proximal humerus)

  - *Destruction pattern:* Lytic, expansile.
  - *Margin of tumor:* Well defined
  - *Corticomedullary delineation:* Lost
  - *Status of cortex:* Thinned out or egg shell
  - *Matrix:* Homogeneous
  - *Zone of transition:* Narrow
  - *Periosteal reaction:* Present (solid-soap bubble septation)
  - *Soft tissue extension:* Absent
- *Treatment options:*
  - *If pathological fracture:* Spontaneous resolution following conservative t/t.
  - Curettage and bone grafting
  - *Inaccessible tumor and for shrinkage of larger tumors:* Repeated arterial embolization.

X-RAY: FIBROUS DYSPLASIA (FIGS 32.7A AND B)

- *Fibrous dysplasia:* Failure of normal lamellar bone formation and abundance of fibrous tissue with flecks of immature bone. May be mono or polyostotic.
  - *Age:* 1st to 3rd decade
  - *Site:* Proximal femur > proximal tibia
  - *Common association:*
    - McCune Albright syndrome—polyostotic fibrous dysplasia with precocious puberty.
    - Mazabraud's syndrome—fibrous dysplasia with myxoma
    - Cherubism (leontiasis ossea)—fibrous dysplasia of jaw.
- *Description of a tumor radiographs:*
  - *Tumor location:* Epiphysis/metaphyseal/diaphyseal
  - *Destruction pattern:* Lytic
  - *Margin of tumor:* Well defined
  - *Corticomedullary delineation:* Lost
  - *Status of cortex:* Some places thinned and some places sclerosed
  - *Matrix:* Ground glass appearance
  - *Zone of transition:* Narrow
  - *Periosteal reaction:* Present (continuous-solid periosteal reaction)
  - *Soft tissue extension:* Absent



Figs 32.7A and B X-ray: Fibrous dysplasia. (A) Proximal femur; (B) Humerus (*Courtesy:* Dr John Mukhopadhyay)

☑ *Note:* A peculiar deformity in fibrous dysplasia involving proximal femur is called **Shepherd crook** deformity.

- *Treatment options:*
  - *Cystic lesion:* Curettage and bone grafting
  - *If pathological fracture:* Orif and bone grafting
  - *Bone deformity:* Osteotomy and fixation with bone grafting
  - *Polyostotic disease:* Intravenous bisphosphonate like pamidronate.

X-RAY: FIBROUS CORTICAL DEFECT (NONOSSIFYING FIBROMA) (FIG. 32.8)

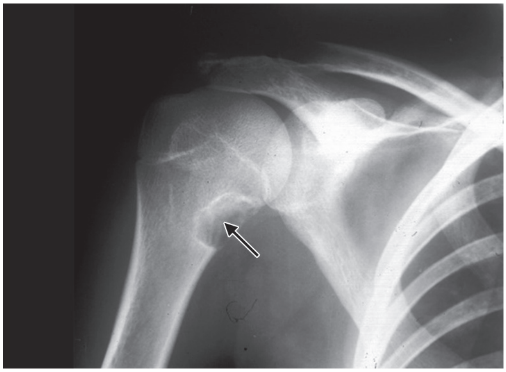


Fig. 32.8 X-ray: fibrous cortical defect (nonossifying fibroma) (proximal humerus) (*Courtesy:* Dr DK Taneja)

- *Osteoid osteoma:* A hamartomatous fibrous tissue forming tumor that disappears after skeletal maturity.
  - *Age:* 1st to 2nd decade
  - *Site:* Long bones
  - Common association:
    - Multiple nonossifying fibroma (NOF) with café-au-lait-spots is called Jaffe Campanacci syndrome.
    - A ossifying fibroma of long bone is called osteofibrous dysplasia. (Campanacci disease)
    - NOF closely resembles chondromyxoid fibroma a locally malignant tumor
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal, eccentric
  - *Destruction pattern:* Lytic (geographical)
  - *Margin of tumor:* Well defined
  - *Cortico-medullary delineation:* Lost
  - *Status of cortex:* Intact (thickened and sclerosed)
  - *Matrix:* Homogenous/multiloculated
  - *Zone of transition:* Narrow
  - *Periosteal reaction:* Present (solid-continuous periosteal reaction)
  - *Soft tissue extension:* Absent

☑ *Note:* If the size of lesion is more than 3 cm, tumor is called non-ossifying fibroma (NOF).

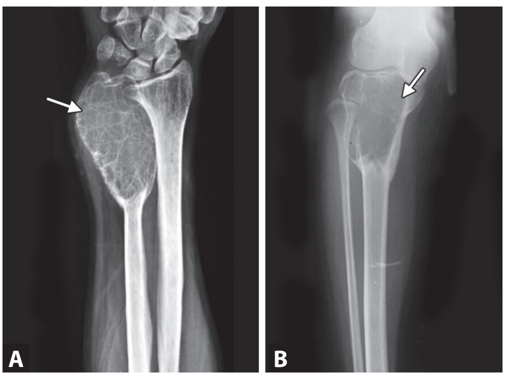
- *Treatment options:*
  - Most lesions—no treatment
  - For larger lesion (>50% of cortex)—prophylactic curettage and bone grafting is done.

X-RAY: GIANT CELL TUMOR (FIGS 32.9A AND B)

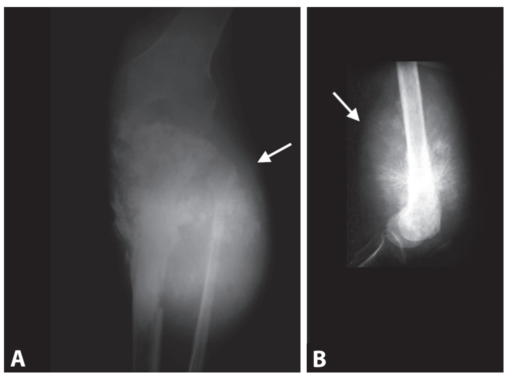
- *Giant cell tumor:* A tumor due to overproliferation of osteoclast cell, hence its other name is it is osteoclastoma.
  - *Age:* 20–40 years (a tumor of mature skeleton)
  - *Site:* Distal femur > proximal tibia > distal radius
  - The aneurysmal bone cyst is one of the tumor of giant cell group that may exist with osteoclastoma.
- *Description of a tumor radiographs:*
  - *Tumor location:* Epiphyseal, metaphyseal in skeletally immature (less common)
  - *Destruction pattern:* Lytic, eccentric and abutting to joint cartilage
  - *Margin of tumor:* Well defined
  - *Corticomedullary delineation:* Lost
  - *Status of cortex:* Intact or may breached at some places
  - *Matrix:* Homogeneous
  - *Zone of transition:* Narrow
  - *Periosteal reaction:* Minimal or absent
  - *Soft tissue extension:* Absent/present
- *Treatment options:*
  - Extended curettage—when curettage is followed by cauterization by following ways:
    - Phenol
    - Liquid nitrogen
    - Burr
    - Electrical
    - Argon laser
  - Dead space management with bone graft (auto and allo), bone substitute, bone cement,
  - En block excision and reconstruction by turn-o-plasty or bone grafting
  - *Inaccessible lesion:* Radiotherapy.

X-RAY: OSTEOSARCOMA (FIGS 32.10A AND B)

- *Osteosarcoma:* A malignant osteoid producing tumor.
  - *Age:* Primary 2nd decade, secondary 5th decade
  - *Site:* Distal femur > proximal tibia > proximal humerus
  - Parosteal osteosarcoma closely resembles myositis ossificans. Characteristic of parosteal osteosarcoma.
    - Common in female
    - Common site—posterior aspect of distal femur
    - Slow growing and painless
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal
  - Destruction pattern: Permeative
  - *Margin of tumor:* Ill defined
  - *Corticomedullary delineation:* Lost
  - *Status of cortex:* Breached
  - Matrix: Heterogeneous
  - *Zone of transition:* Wide



Figs 32.9A and B X-ray: Giant cell tumor. (A) Distal ulna; (B) Proximal tibia (*Courtesy:* Dr Chandan Sekhar)



Figs 32.10A and B X-ray: Osteosarcoma. (A) Proximal tibia; (B) Distal femur (*Courtesy:* Dr John Mukhopadhyay)

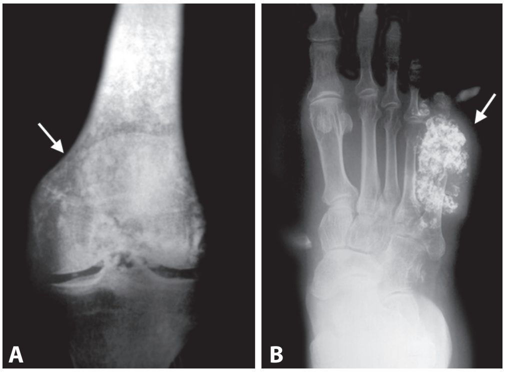
- *Periosteal reaction:* Interrupted type (Codman triangle) and spiculated type (sun burst appearance)
- *Soft tissue extension:* Present
- *Treatment options:*
  - Neo-adjuvant chemotherapy followed by wide resection of tumor and post-operative chemotherapy.
    - T-10 a/b regimen are commonly followed as T-10 a (methotrexate, Adriamycin, ifosfamide and dexamethasone)
    - T-10 b (above drugs + cisplatin)
  - Reconstruction with bone graft (autograft and allograft) and endoprosthesis.
  - Resection arthrodesis and rotationplasty
  - Amputation of limb

X-RAY: CHONDROSARCOMA (FIGS 32.11A AND B)

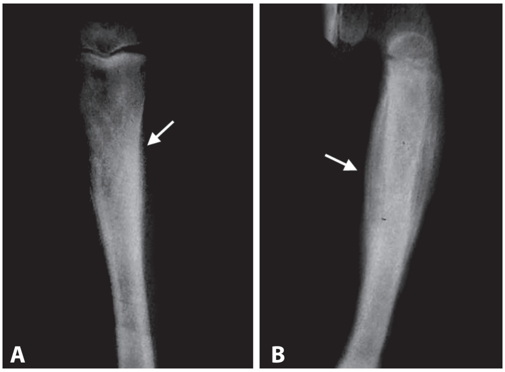
- *Chondrosarcoma:* Malignant chondroid forming tumor.
  - *Age:* Primary—5th to 7th decade, Secondary—younger to elderly
  - *Site:* Pelvic girdle > proximal femur > proximal humerus
  - Clear cell chondrosarcoma closely mimics chondroblastoma. Characteristic of clear cell sarcoma:
    - Common in male
    - Common site—epiphysis of femoral head
    - Low-grade
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal
  - *Destruction pattern:* Moth eaten
  - *Margin of tumor:* Ill defined
  - *Corticomedullary delineation:* Lost
  - *Status of cortex:* Thin and breached
  - *Matrix:* Heterogeneous (punctate, pop-corn calcification)
  - *Zone of transition:* Wide
  - *Periosteal reaction:* Present (continuous-solid periosteal reaction)
  - *Soft tissue extension:* Present
- *Treatment options* (no role of chemotherapy or radiotherapy)
  - Wide resection of tumor and limb salvage procedure.
  - Amputation of limb.

X-RAY: EWING SARCOMA (FIGS 32.12A AND B)

- *Ewing sarcoma:* A tumor of neuroectodermal origin
  - *Age:* 1st to 3rd decade (10–20 yr)
  - *Site:* Flat bones > long bones
  - These tumor can be mistaken for acute osteomyelitis.
- *Description of a tumor radiographs:*
  - *Tumor location:* Metaphyseal/diaphyseal
  - *Destruction pattern:* Permeative
  - *Margin of tumor:* Ill defined



Figs 32.11A and B X-ray: Chondrosarcoma. (A) Distal femur; (B) Metatarsal (*Courtesy:* Dr DK Taneja)



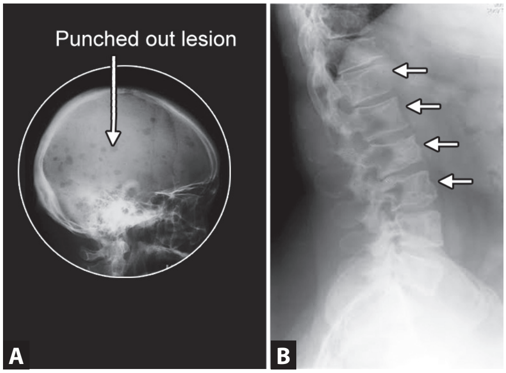
Figs 32.12A and B X-ray: Ewing sarcoma (femur) (*Courtesy:* Dr John Mukhopadhyay)

– *Corticomedullary delineation:* Lost
– *Status of cortex:* Breached
– *Matrix:* Heterogeneous
– *Zone of transition:* Wide
– *Periosteal reaction:* Present (continuous-lamellated periosteal reaction or onion peel appearance, spiculated type—sun-burst appearance and hair on end appearance.)
– *Soft tissue extension:* Present (massive soft tissue)

- *Treatment options:*
  – Radiotherapy for local control
  – Chemotherapy for micro-metastasis control
  – Wide resection of tumor and limb salvage procedure.
  – Amputation of limb.

X-RAY: MULTIPLE MYELOMA (FIGS 32.13A AND B)

- *Multiple myeloma:* A proliferative disorder of plasma cell.
  – *Age:* 6th to 7th decade
  – *Site:* Spine >proximal femur > proximal humerus
  – Secondary metastasis in the spine mimic multiple myeloma. In bone scan multiple myeloma are almost cold contrary to other metastasis.
- *Description of a tumor radiographs:*
  – *Tumor location:* Metaphyseal
  – *Destruction pattern:* Lytic (multiple)
  – *Margin of tumor:* Well defined (punched out)
  – *Corticomedullary delineation:* Lost



Figs 32.13A and B X-ray: Multiple myeloma: (A) Skull; (B) Spine (*Courtesy:* Dr Shailendra Gupta)

  – *Status of cortex:* Breached at some places
  – *Matrix:* Heterogeneous
  – *Zone of transition:* Wide
  – *Periosteal reaction:* Absent
  – *Soft tissue extension:* May present
- *Treatment options:*
  – Chemotherapy is mainstay of treatment. (VAD regimen—vincristine, adriamycin, doxorubicin and dexamethasone)
  – Prophylactic or definitive fixation followed by adjuvant radiotherapy
  – *Other supportive treatment modalities are as follows:*
    - Dehydration— t/t with fluid therapy
    - Infection— t/t with antibiotic therapy
    - Anemia— t/t with erythropoietin
    - Hypercalcemia—t/t with steroid, natriuretics and hydration
    - Bone building—with bisphosphonate like intravenous pamidronate.

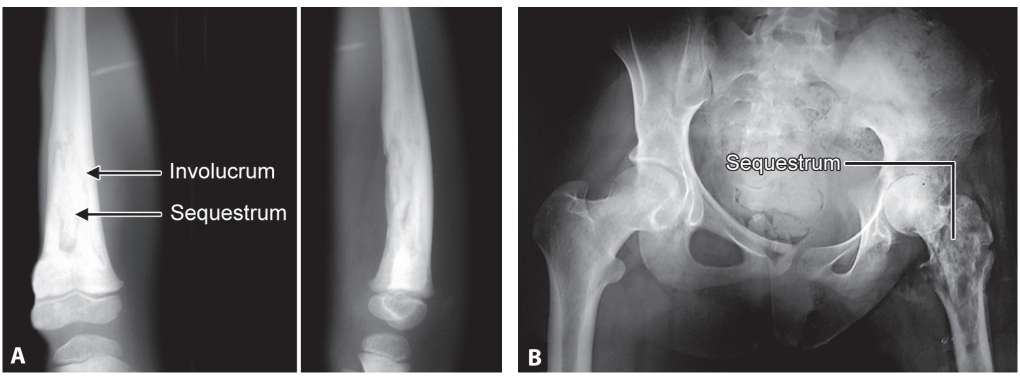
CHAPTER

33

Radiographs of Infective and Rheumatic Disorders

X-RAY: CHRONIC OSTEOMYELITIS (FIGS 33.1A AND B)

- *Chronic osteomyelitis:* To ascertain a bone suffering from chronic osteomyelitis; there should be a dead bone surrounded by thick periosteum and fibrosed muscle and subcutaneous tissue.
- *X-ray description:*
  - Cortical thickening
  - Cortical irregularity
  - Cortical sclerosis
  - Obliteration of medullary cavity
  - Sequestrum
  - Involucrum
- *Treatment principles:*
  - Debridement of necrotic part (sequestrectomy and saucerization)
  - Dealing with dead space
  - Soft tissue coverage
  - Stabilization of bone
  - Dealing with complication
  - *Other methodologies are:*
    - Debridement and closed suction irrigation
    - Ilizarov method
    - Excision of bone, e.g. fibula
    - Amputation.



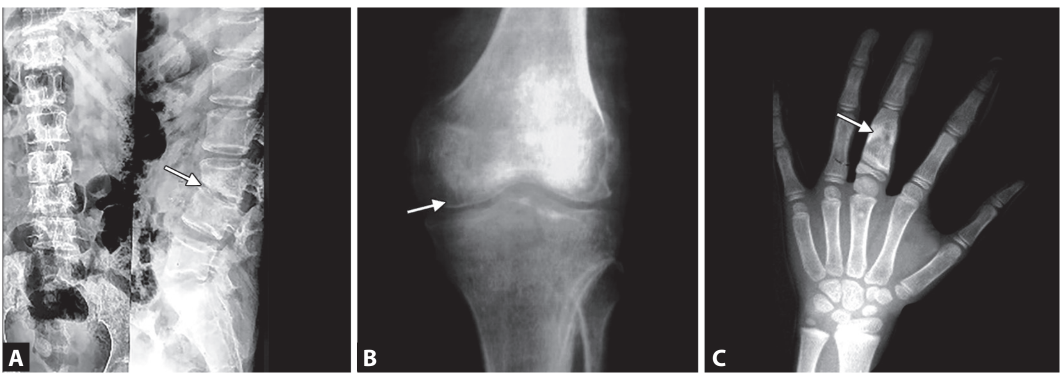
Figs 33.1A and B X-ray: Chronic osteomyelitis: (A) Distal femur; (B) Proximal femur (*Courtesy:* Dr John Mukhopadhyay)

X-RAY: OSTEOARTICULAR TUBERCULOSIS (FIGS 33.2A TO C)

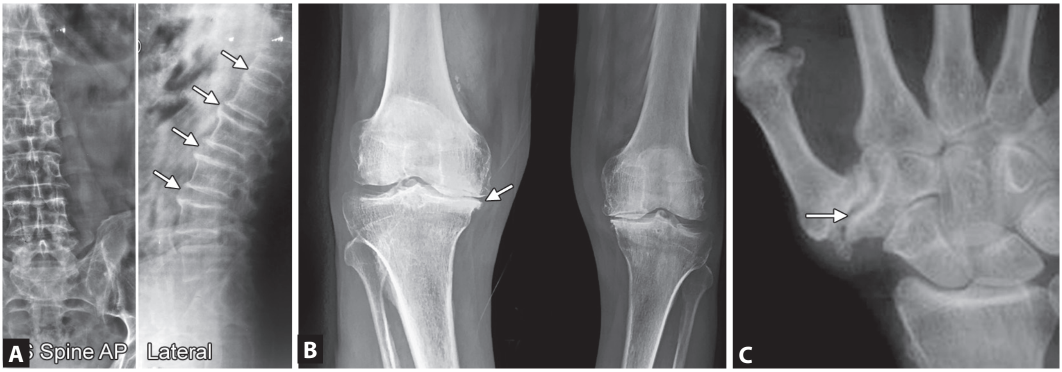
- *Tuberculosis of joints:* Tubercular arthritis is always secondary with primary foci either in lung or lymph node.
- *X-ray description:*
  - Phemister's triad
    - Gradual dimunition of joint space
    - Juxta-articular osteoporosis
    - Peripherally located osseous erosion
  - Sequential changes in radiographs as TB advances from synovitis—to arthritis—to erosive stage
    - Increased joint space due to effusion
    - Periarticular osteoporosis
    - Gradual narrowing of joint space
    - Subchondral erosion
    - Joint subluxation and dislocation
    - Fibrous ankylosis in peripheral joint
    - Bony ankylosis in spine
  - Tubercular dactylitis—spina ventosa (air filled small bones)
    - Diaphyseal location
    - Expansile lesion
    - Periosteal reaction rare
    - Cortical sclerosis present in healing phase
- *Treatment principle:*
  - Antitubercular treatment
  - Traction and splintage
  - Incision and drainage
  - Debridement
  - Stabilization of bone.

X-RAY: DEGENERATIVE ARTHRITIS (FIGS 33.3A TO C)

- *Degenerative arthritis:* A disease of joint cartilage destruction and new bone formation.
- *X-ray description:*
  - *Characteristic radiological feature of degenerative joint:*
    - Narrowing of joint space
    - Subchondral sclerosis
    - Subchondral cyst formation
    - Osteophyte formation (horizontal osteophyte)
    - Loose bodies
    - Collapse of weight-bearing bone
    - Joint subluxation
    - Deformity at joint.
- *Treatment options:*
  - Analgesics (NSAIDs and opioids)
  - Cartilage forming drugs
  - Physiotherapy and habit changes
  - Joint debridement.
  - Intra-articular injections (viscosupplement and steroids)
  - Osteotomy, arthrodesis and arthroplasty.



Figs 33.2A to C X-ray—Osteoarticular tuberculosis: (A) Pott's spine; (B) TB knee; (C) Spina ventosa (*Courtesy:* Dr Shailendra Gupta)



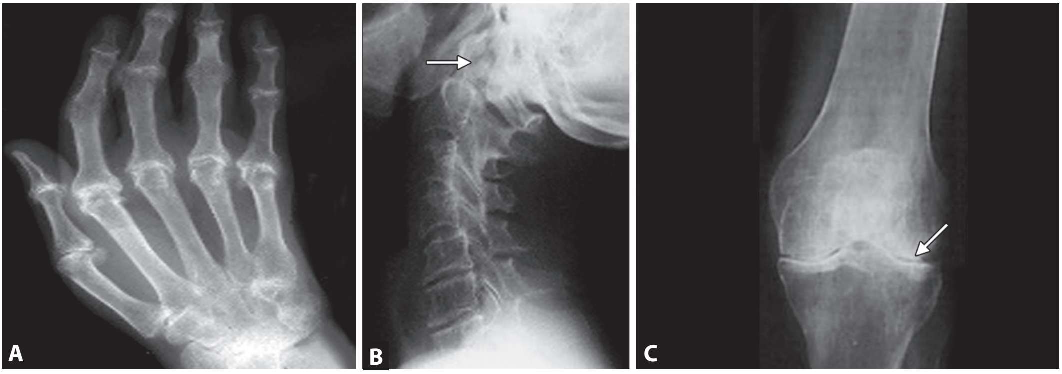
Figs 33.3A to C X-ray—Degenerative arthritis: (A) Lumbar spondylosis; (B) Osteoarthritis knee; (C) First carpometacarpal arthritis (*Courtesy:* Dr Ajay Rajput)

X-RAY: RHEUMATOID ARTHRITIS (FIGS 33.4A TO C)

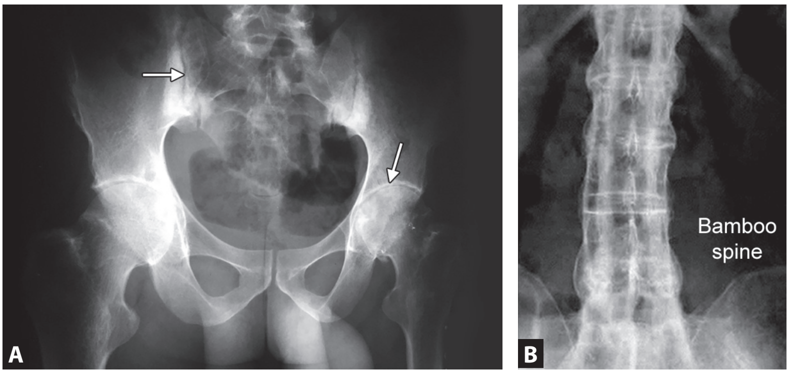
- *Rheumatoid arthritis:* A polyarthralgia of autoimmune etiology primarily involving synovium (pannus formation) and leading to joint destruction.
- *X-ray description:*
  - *Characteristic radiological feature of rheumatoid joint:*
    - Soft tissue swelling—earliest changes
    - Juxta-articular osteoporosis
    - Symmetrical diminution of joint space
    - Marginal erosion—due to pannus formation
    - Subchondral cyst may present
    - Joint subluxation and dislocation
    - Joint deformity
  - *Radiology of rheumatoid hand:*
    - Swan neck deformity
    - Boutonniere deformity
    - Ulnar deviation of fingers at metacarpophalangeal joint
    - Z deformity of fingers
    - Hitchhiker's thumb (hyperextension at interphalangeal joint)
    - Ankylosis of small joints
    - Instability of wrist
  - In Juvenile rheumatoid arthritis unlike adult, growth retardation along with epiphyseal over growth (prominent condyles) is a main feature.
- *Treatment options:*
  - Analgesics (NSAIDs and opioids)
  - Disease modifying drugs
  - Biologics
  - Physiotherapy and habit change
  - Osteotomy, arthrodesis and arthroplasty.

X-RAY: ANKYLOSING SPONDYLITIS (FIGS 33.5A AND B)

- *Ankylosing spondylitis:* A seronegative spondyloarthropathy involving both sacroiliac joint, spine hip, etc. also called **Bechterew's** disease or **Marie Strumpell** syndrome.
- *X-ray description:*
  - *Characteristic radiological feature of sacroiliac joint*:
    - Blurring of joint margins
    - Erosion
    - Sclerosis
    - Ankylosis
  - *Characteristic radiological feature of spine:*
    - Squaring of dorsolumbar vertebrae body (earliest change)
    - *Syndesmophyte formation:* Vertical new bone formation)



Figs 33.4A to C X-ray: Rheumatoid arthritis: (A) Rheumatoid hand; (B) Rheumatoid upper cervical spine; (C) Rheumatoid knee
(*Courtesy:* Dr Khuswant Rathore)



Figs 33.5A and B X-ray: Ankylosing spondylitis: (A) Hip and sacroiliac joint; (B) Bamboo spine
(*Courtesy:* Dr John Mukhopadhyay)

- *Bamboo spine appearance:* Due to ossification of anterior and posterior longitudinal ligament, facet joint
- *Romanus lesion:* Early erosive changes in anterior and posterior edges of vertebral body
- *Anderson's lesion:* Erosive lesion in superocentral and inferocentral part of body
- *Dagger sign:* Interspinous and supraspinous ligament calcification
- Diffuse osteoporosis
- Pathological fracture with pseudo-arthrosis

Although alkaptonuria (ochronosis) radiographs appears similar to ankylosing spondyltis…but points to taken care for ochronosis are
- Dystrophic ossification of joint cartilage, intervertebral disc, ligament and tendons.
- Wide band like ossification of intervertebral disc.
- A radiolucent vaccum like area (vaccum phenomenon) in intervertebral disc due to gas collection.

Treatment options:
- Analgesics (NSAIDs and Opioids)
- Disease modifying drugs (sulfasalazine) and biologics
- Physiotherapy and habit change
- Osteotomy, arthrodesis and arthroplasty.

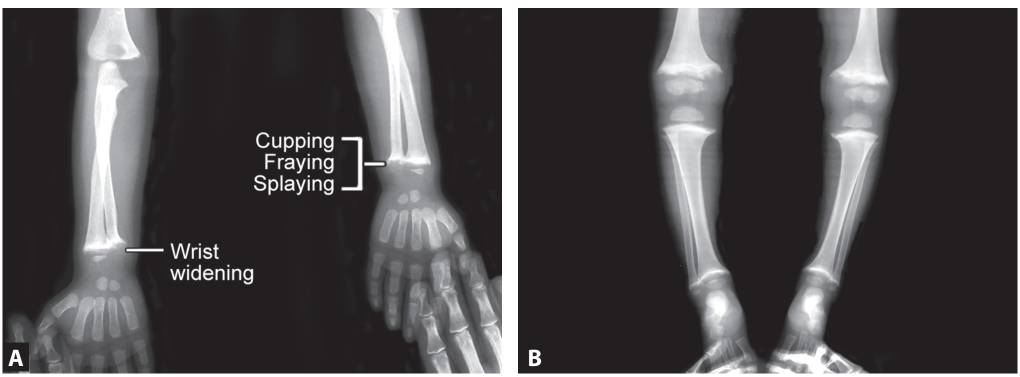
CHAPTER

34

Radiographs of Metabolic and Osteochondritic Disorders

X-RAY: NUTRITIONAL RICKETS (FIGS 34.1A AND B)

- *Rickets:* Failure of mineralization of osteoid matrix in immature skeleton.
- *X-ray description:*
  - *Common feature:* Generalized rarefaction (ground glass appearance).
  - *Skull:*
    - Frontal bossing
    - Craniotabes.
  - *Rib cage:*
    - Pectus carinatum (pigeon chest)
    - Rachitic rosary.
  - *Spine:*
    - Kyphoscoliosis
    - Increased lumbar lordosis (Pott's belly).
  - *Long bone:*
    - Bowing of bone
    - Changes in end of long bone as cupping, fraying and splaying
    - Deformities like genu valgus, varus, or wind swift deformity.
- *Treatment options:*
  - Drugs (calcium and vitamin D supplement)
  - Sun bath
  - Splintage
  - Epiphysiodesis
  - Osteotomy.



Figs 34.1A and B X-ray: Nutritional rickets. (A) Wrist; (B) Knee and ankle (*Courtesy:* Dr Naresh Chandra)

X-RAY: SCURVY (FIG. 34.2)

- *Scury:* Occur due to dietary deficiency of vitamin C, also called Barlow's disease. The combined deficiency of vitamin C and D is called Barton's disease.
- *X-ray description:*
  - *Common feature:* Generalized rarefaction (common in adult).
  - *Long bones:*
    - Pencil thin cortex (common in adult)
    - Periosteal reaction following sub-periosteal hemorrhage.
  - Chest X-ray—scorbutic rosary
  - *Periarticular changes:*
    - *Ring sign of **Wimberger**:* A radiodense area around epiphyseal ossification center
    - *White line of **Frankel**:* A dense and wide zone of provisional calcification
    - *Zone of **Trummerfeld**:* A radiolucent area adjacent to Frankel line
    - ***Pelken** spur:* Metaphyseal corner formed due to splaying.
- *Treatment options:*
  - Analgesics (NSAIDs and Opioids)
  - Vitamin C supplementation
  - Vitamin C rich diet.

X-RAY: OSTEOMALACIA (FIG. 34.3)

- *Osteomalacia:* Failure of mineralization of osteoid matrix in mature skeleton
- *X-ray description:*
  - *Common feature:* Generalized rarefaction (ground glass appearance)
  - *Long bone:* Bowing of shaft
  - *Spine:*
    - Kyphoscoliosis
    - Biconcave vertebrae (cod fish/fish mouth appearance).
  - *Pelvis:*
    - Protrussio acetabulli
    - Trefoil pelvis (Champagne glass pelvis).
  - *Looser's Zone:*
    - Pseudo-fracture or Milkman's fracture)
    - *Common sites are:* Ribs, scapula, pubic rami, ischium and neck of femur
    - *Characteristic of Looser's zone are:*
      - Incomplete and transverse fracture
      - Oftenly bilaterally symmetrical
      - Healing by inappropriate callus formation.
- *Treatment options:*
  - Calcium and vitamin D supplementation,
  - Dealing with complication.

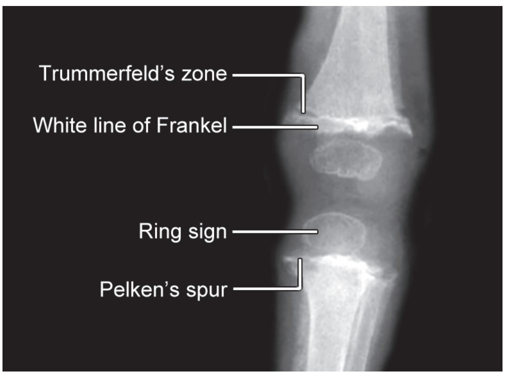


Fig. 34.2 X-ray: Scurvy (knee)
(*Courtesy:* Dr Nitesh Rustag)

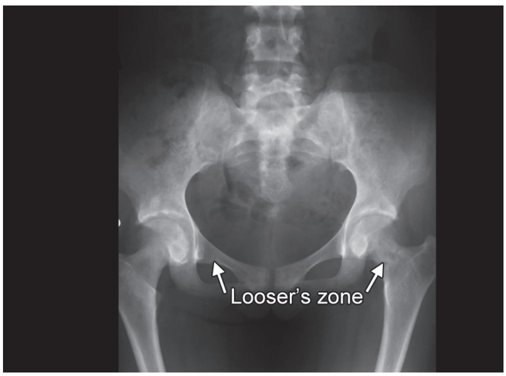


Fig. 34.3 X-ray: Osteomalacia (Pelvis)
(*Courtesy:* Dr Nitesh Rustag)

X-RAY: OSTEOPOROSIS (FIGS 34.4A AND B)

- *Osteoporosis:* Deficient bone matrix with normal mineralization.
- *X-ray description:*
  - *Common feature:* Generalized rarefaction (ground glass appearance).
  - *Long bone:*
    - Pencil thin cortex
    - Pathological fracture.
  - *Spine:*
    - Kyphoscoliosis
    - Vertical compression of vertebrae
    - Anterior wedge compression of vertebrae
    - Biconcave vertebrae (cod fish/fish mouth appearance).
- Trabeculae pattern in femoral neck and Singh and Maini index
  - Types of trabeculae in AP view: (Fig. 34.4B)
    - Primary compression trabeculae
    - Primary tensile trabeculae
    - Secondary compressive trabeculae
    - Secondary tensile trabeculae
    - Trochanteric trabeculae
  - Loss of trabeculae of femoral neck and *Singh and Maini index:*

Singh and Maini index
• Grade VI—all trabeculae are present-normal
• Grade V—loss of trochanteric and secondary tensile but attenuation of secondary compressive
• Grade IV—loss of secondary compressive but attenuation of primary tensile
• Grade III—break in primary tensile: definite osteopenia
• Grade II—marked loss in primary tensile
• Grade I—only primary compressive trabeculae present but reduced.

- *Treatment options:*
  - Calcium and vitamin D supplementation
  - Bisphosphonates
  - Calcitonin
  - Hormone replacement therapy
  - Bracing
  - Dealing with complication
  - Physiotherapy and habit change.

X-RAY: PRIMARY HYPERPARATHYROIDISM (FIGS 34.5A AND B)

- *Hyperparathyroidism:* Condition arises due to increased secretion of parathormone

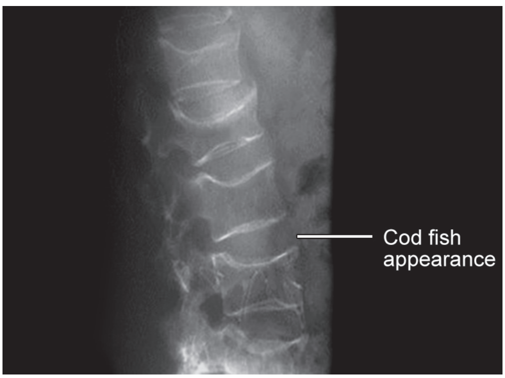


Fig. 34.4A X-ray: Osteoporosis (spine)

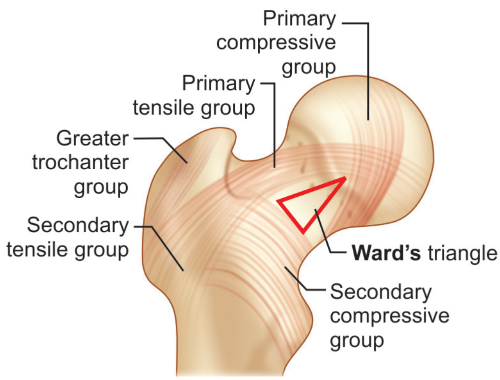
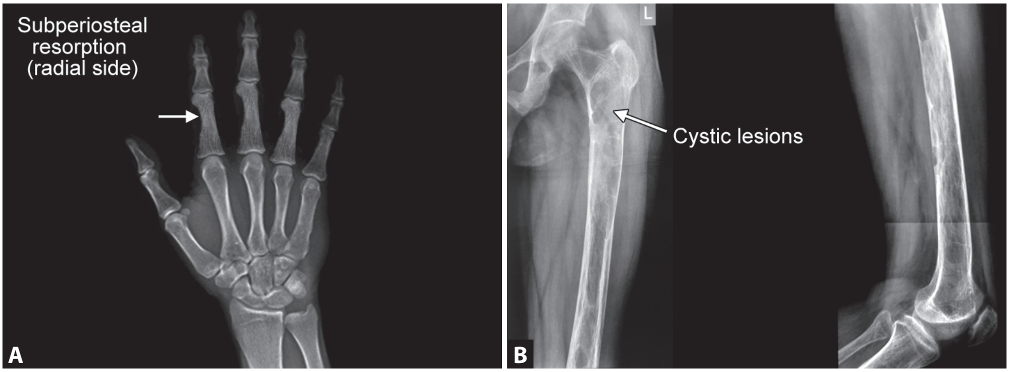


Fig. 34.4B Trabeculae pattern in femur neck



Figs 34.5A and B X-ray: Primary hyperparathyroidism. (A) Phalanx; (B) Femur
(*Courtesy:* Dr John Mukhopadhyay)

following parathyroid disorders like hyperplasia, adenoma, carcinoma, etc.

- *X-ray description:*
  - *Common features:*
    - Generalized rarefaction
    - Sub-periosteal resorption of bone
    - Involvement of radial border of middle phalanx of index and middle finger (characteristics).
  - *Skull:*
    - Diffuse osteoporosis
    - Pin head stippling of skull (salt and pepper appearance).

Brown tumor
• This is also called osteitis fibrosa cystica or Von Recklinghausen's disease
• Cavity is filled with osteoclast and blood degradation product
• Common sites are—clavicle, mandible, ribs, pelvis, femur

- *Treatment options:*
  - Calcium and vitamin D supplementation
  - Phosphate restriction
  - Surgery like parathyroidectomy.

X-RAY: MYOSITIS OSSIFICANS (FIGS 34.6A TO C)

- *Myositis ossificans:* New bone formation in places where it does not occur normally. Elbow is the most common site.

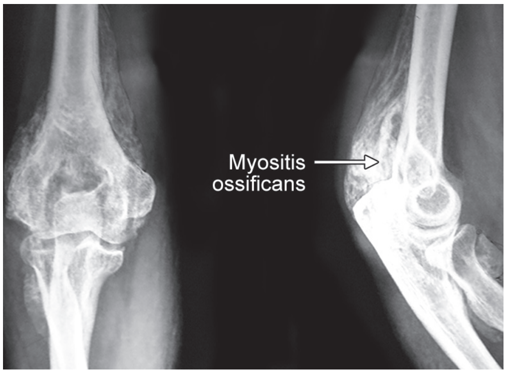


Fig. 34.6A X-ray: Myositis ossificans (elbow)
(*Courtesy:* Dr Tarun Solanki)

- *X-ray description:*
  - *Early phase:*
    - Before 6 weeks
    - Faint soft tissue ossification.
  - *Late phase:*
    - After 6 weeks
    - Well-defined bony margin.

• Tumor calcinosis is the most common D/D for myositis ossificans (Fig. 34.6B). – It is metastatic calcification around joint – Common sites are hip, ankle and shoulder – It is associated with hyperphosphatemia • Loose bodies also look like myositis masses (Fig. 34.6C) – These are osteocartilaginous or bony – These are discrete well defined intra-articular masses

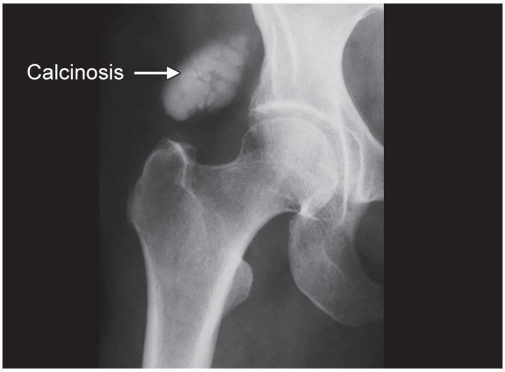


Fig. 34.6B X-ray: Tumor calcinosis around hip

Fig. 34.6C X-ray: Loose bodies around knee

Treatment options:
- Analgesics (NSAIDs and Opioids)
- Low dose radiotherapy
- Surgical excision of myositis mass.

X-RAY: OSTEOGENESIS IMPERFECTA (FIG. 34.7)

- *Osteogenesis imperfecta:* Due to defective collagen I fiber; there is failure of osteoblast formation during endochondral ossification leading to defective osteoid matrix production.
- *X-ray description:*
  - Radiographic features of long bone are as:
    - Osteoporosis
    - Multiple bowing bone
    - Multiple pathological fracture
    - Multiple bony swelling (calluses formation)
    - Popcorn calcification in epiphysis and metaphysis
    - On the basis of cortical changes it may be classified as:
      - Thin bone type
      - Thick bone type
      - Cystic type
  - Skull—Wormian bone
  - Spine:
    - Kyphoscoliosis
    - Biconcave spine (cod fish vertebrae) with compression fracture

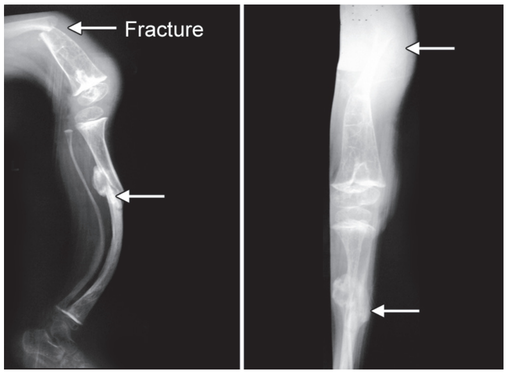


Fig. 34.7 X-ray: Osteogenesis imperfecta (femur and tibia)
(*Courtesy:* Dr Kumar Kaushik)

  - *Chest:* Pectus excavatum and carinatum
  - Pelvis
    - Protrussio acetabulli
    - Coxa vara
  - Multiple dentigerous defect.
- *Treatment options:*
  - Bisphosphonate (pamidronate), teriparatide and growth hormone supplementation.
  - Prophylactic bracing.
  - Sofield Miller osteotomy (KABAB osteotomy).
  - Sheffield expanding intramedullary rod system.
  - Bailey and Dubow telescoping intramedullary rod.

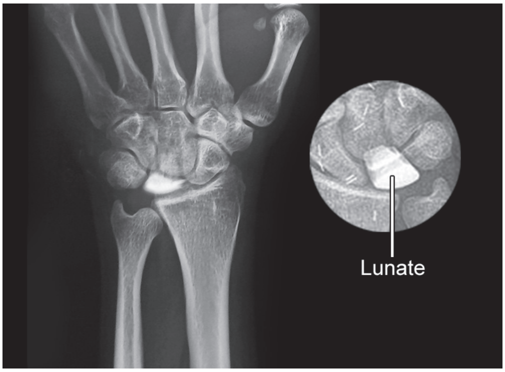


Fig. 34.8 X-ray: Kienbock's disease (lunate) (*Courtesy:* Dr Piyush)

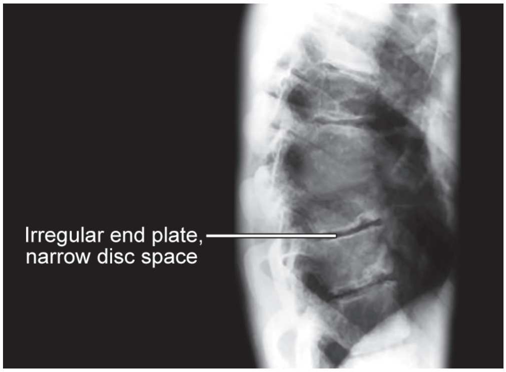


Fig. 34.9 X-ray: Scheuermann's disease (Dorsal spine) (*Courtesy:* Dr Anurag Sharma)

X-RAY: KIENBOCK'S DISEASE (FIG. 34.8)

- *Kienbock disease:* Osteochondritis of lunate.
- *X-ray description:* Typical changes seen in lunate bone are:
  - Sclerosis
  - Fragmentation
  - Collapse.

***Stahl and Lichtman** classification:*
Stage I: Normal radiographs
Stage II: Increased density of lunate or decreased height on radial side
Stage IIIA: Lunate collapse but no rotation of scaphoid
IIIB: Lunate collapse with fixed rotation of scaphoid
Stage IV: Degenerative changes around lunate

- *Treatment options:*
  - Wrist immobilization
  - *Joint leveling procedure:*
    - Radial shortening
    - Ulnar lengthening
    - Capitate shortening
    - Radial wedge osteotomy
  - Revascularization procedure
  - STT (scapho trapezio trapezoid) fusion
  - Proximal row carpectomy
  - Wrist arthrodesis.

X-RAY: SCHEUERMANN'S DISEASE (FIG. 34.9)

- *Scheuermann's disease:* Osteochondritis of ring epiphysis of vertebrae.
- *X-ray description:*
  - ***Sorenson** radiographic criteria for diagnosis:*
    - Thoracic kyphosis >40°
    - Thoracolumbar kyphosis >30°
    - Anterior wedging of >5° of three adjacent vertebrae
    - Vertebral end plate irregularity
    - Intervertebral disc space narrowing.
  - *Other radiographic finding associated with Scheuermann's disease are:*
    - Scoliosis
    - Spondylolisthesis
    - Schmorl node
    - Limbus vertebrae (bone defect in vertebral body look like a fracture).
- *Treatment options:*
  - Exercise
  - Bracing
  - Surgical decompression and spinal stabilization (fusion/instrumentation).

X-RAY: OSTEOCHONDRITIS

DESSICANS OF KNEE (FIG. 34.10)

- *Osteochondritis dessicans knee:* Osteochondritis of lateral part of medial condyle of femur.
- *X-ray description:* Based on staging of disease.

***Berndt and Harty** classification of osteochondritis dessicans*
• *Stage I:* Compression lesion without visible fragment
• *Stage II:* Fragment attached
• *Stage III:* Fragment detached but undisplaced
• *Stage IV:* Displaced fragment

- *Treatment options:*
  - Knee immobilization
  - Physiotherapy
  - Debridement and bone grafting along with fixation of bonegraft
  - Osteochondral autograft
  - Autologous chondrocyte implantation.

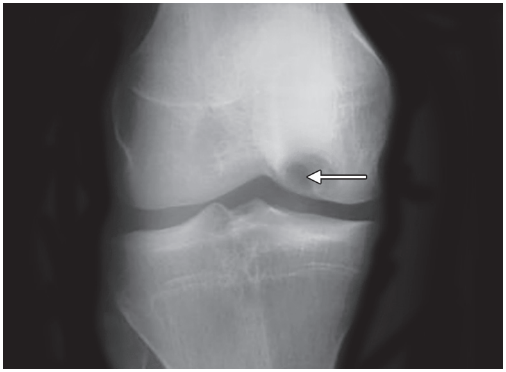


Fig. 34.10 X-ray: Osteochondritis dessicans of knee (medial condyle of femur)

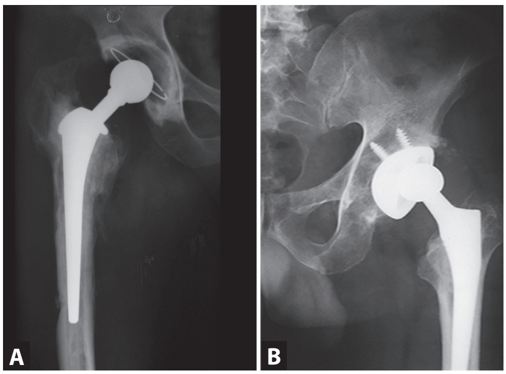
CHAPTER

35

Radiographs of Special Surgical Procedure

X-RAY: TOTAL HIP ARTHROPLASTY (FIGS 35.1A AND B)

- *Radiographic description:*
  - *Status of bone around hip joint:*
    - Good bone stock
    - Osteoporosis
    - Osteolysis
- *Implant related description:*
  - *Type of implant:*
    - Cemented total hip replacement (THR)—both femoral and acetabular component cemented
    - Uncemented THR—both femoral and acetabular component press fit type
    - Hybrid THR—femoral component cemented but acetabular component uncemented
  - Level of acetabular component
  - Eccentricity of head
  - Acetabular and femoral anteversion
  - Cement mantle
  - Implant loosening
- *Preoperative radiographic templating:*
  - Radiographic view
    - AP view of pelvis with both hip joint with 15° internal rotation of femur
    - False profile view—standing position view, affected hip lies against cassette, pelvis tilted 65° external rotation, beam centering over affected head
  - *Look for:*
    - Bone stock—osteoporosis



Figs 35.1A and B X-ray total hip arthroplasty: (A) Cemented; (B) Uncemented (*Courtesy:* Dr Anand Shankar)

    - Acetabulum—acetabular floor, acetabular migration, protrusio—acetabuli osteophyte, acetabulum cup size
    - Look at femur—femoral neck length, neck-shaft angle, medullary cavity in metaphyseal and diaphyseal area, ratio of width of cortex and medullary cavity

***Dorr's** classification*

- Dorr type A—thick cortex with small canal diameter (uncemented implant)
- Dorr type B—typical cortex and canal geometry (for young uncemented and for elderly cemented implant)
- Dorr type C—thin cortex with large canal diameter (cemented implant)

- *Important steps of templating:*
  - Draw two parallel horizontal line at the level of both lesser trochanter—vertical difference in two lines shows limb length discrepancy.
  - Acetabular cup selection—cup size that closely matches with template is chosen, in case of hip ankylosis the tear drop resembles with the medial surface of cup and obturator foramen limits the inferior margin of cup.
  - Femoral component selection—on the basis of difference of medullary cavity in metaphyseal and diaphyseal area, 2–3 mm cement mantle.
  - Neck size—on basis of femoral neck length and vertical and medial offset
  - Level of femoral neck cutting—measure the distance between anticipated neck cut marking and lesser trochanter.

- *Indication of THR:*
  - *Arthritis following:* Trauma, infection both pyogenic or tubercular, degenerative, rheumatic, metabolic or osteochondritic, genetic and dysplastic disorder
  - *Others:*
    - Failed reconstruction of femoral neck or acetabulum
    - Revision arthroplasty
- *Contraindication of THR:*
  - *Absolute:*
    - Sever medical illness
    - Active hip infection
  - *Relative:*
    - Rapidly bone destroying disorder
    - Progressive neurological disorder
    - Neuropathic arthropathy
    - Abductor insufficiency
    - Young individual with higher expectation
- *Complication of THR:*
  - *Early complication:*
    - Nerve injury
    - Hematoma formation
    - Thromboembolism
    - Mortality
  - *Late complication:*
    - Loosening
    - Osteolysis
    - Heterotrophic ossification
    - Component failure
  - *Time independent complication:*
    - Infection
    - Dislocation
    - Limb-length discrepancy
    - Fracture
    - Trochanteric nonunion.

X-RAY: TOTAL KNEE ARTHROPLASTY (FIGS 35.2A AND B)

- *Radiographic description:*
  - *Status of bone around knee joint:*
    - Good bone stock
    - Osteoporosis
    - Osteolysis
  - *Implant related description:*
    - *Type of implant:*
      - *Unconstrained:* Where ligament and muscle around knee are functioning well
      - *Constrained:* Where ligament and muscle status are severely compromised.
    - Notching of femoral component
    - Tibiofemoral component alignment
    - Cement mantle
    - Implant loosening.

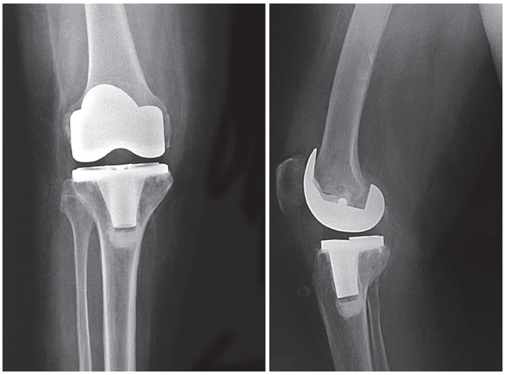


Fig. 35.2A X-ray: Total knee arthroplasty (*Courtesy:* Dr Anand Shankar)

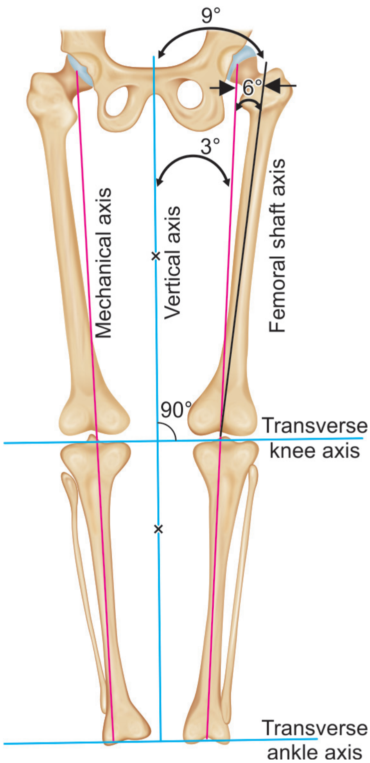


Fig. 35.2B Anatomical axis, mechanical axis and vertical axis of lower limb

- *Preoperative radiographic assessment:*
  - *Radiographic view:* Standing AP view extending from pelvis to ankle

Arthrogram	*Scanogram*
Standing position	Recumbent position
Single exposure	Three separate exposure for hip, knee and ankle
Three standard size cassettes stacked one above other or single 51″ film	Standard size film

  - *Look for:*
    - Bone stock
    - *Anatomical axis, mechanical axis and vertical axis: (Fig. 35.2B)*
      - Angle between vertical axis and anatomical axis—9°
      - Angle between vertical axis and mechanical axis—3°
      - Angle between anatomical axis and mechanical axis—6°
      - Angle between tibiofemoral axis 5°–6°.
- *Indications:*
  - *Arthritis following:* Trauma, infection both pyogenic or tubercular, degenerative, rheumatic, metabolic or osteochondritic, genetic and dysplastic disorder
  - *Others:*
    - Failed osteotomy around knee
    - Revision arthroplasty (e.g. unicondylar arthroplasty)
- *Contraindication:* Absolute contraindication for total knee replacement (TKR):
  - Active or inactive knee infection or some remote source of infection in body
  - Sever dysfunction of extensor mechanism
  - Genu recurvatum deformity due to muscular weakness
  - Painless and functioning arthrodesed knee
  - Inadequate skin coverage at operative site.
- *Complications:*
  - *Early complication:*
    - Thromboembolism
    - Neurovascular complication
  - *Time independent complication:*
    - Infection
    - Peri-implant fracture
  - *Patellofemoral complication:*
    - Patellar subluxation or maltracking of patella
    - Patellar fracture
    - Patellar component failure (metal backed implant)
  - *Patellar component loosening:*
    - Patellar clunk syndrome **(Hozac et al.)**.

X-RAY: TOTAL SHOULDER ARTHROPLASTY (FIGS 35.3A AND B)

- *Radiographic description:*
  - *Status of bone around shoulder joint:*
    - Good bone stock
    - Osteoporosis

        - Osteolysis
    - *Implant related description:*
        - *Type of implant:*
            - *Conventional TSA:* Where rotator cuff functioning well
            - Reverse shoulder arthroplasty—where rotator-cuff function is severely compromised.
        - Incongruency of humero-glenoid component, i.e. proximal migration of humeral component
        - Notching of scapula
        - Cement mantle
        - Implant loosening
- *Preoperative radiographic assessment:*
    - *Radiographic view:*
        - AP view, lateral view and axillary view
    - *Angle measurement like:*
        - Head shaft angle–135°
        - *Angle of retroversion:* 20°–30°
- *Indication of TSA:*
    - *End stage glenohumeral arthritis following:*
        - Trauma, infection both pyogenic or tubercular, degenerative, rheumatic, metabolic or osteochondritic, genetic and dysplastic disorder
    - Indication for reverse shoulder arthroplasty
        - End stage shoulder arthritis with rotator cuff dysfunction
        - Failed shoulder arthroplasty
        - Rotator cuff tear arthropathy
- *Contraindication:* Contraindication for TSA
    - Active or recent infection
    - Sever dysfunction of rotator cuff mechanism (only RSA can be done)
    - Deltoid muscle dysfunction
    - Neuroparalytic shoulder disorder
    - Neuropathic shoulder joint
- *Complication:*
    - *Chief complication:*
        - Infection
        - Joint stiffness
        - Shoulder instability
    - *Soft tissue related complication:*
        - Deltoid dysfunction
        - Heterotopic ossification
        - Rotator cuff tear
    - *Implant related complication:*
        - Implant loosening
        - Periprosthetic fracture
        - Notching of inferior part of scapular neck with acromial stress # (related to RSA).

X-RAY: ELBOW ARTHROPLASTY (FIGS 35.4A AND B)

- *Radiographic description:*
    - *Status of bone around elbow:*
        - Good bone stock
        - Osteoporosis
        - Osteolysis
    - *Implant related description:*
        - *Type of implant:*
            - Unconstrained (unlinked) implant-where good bone stock with

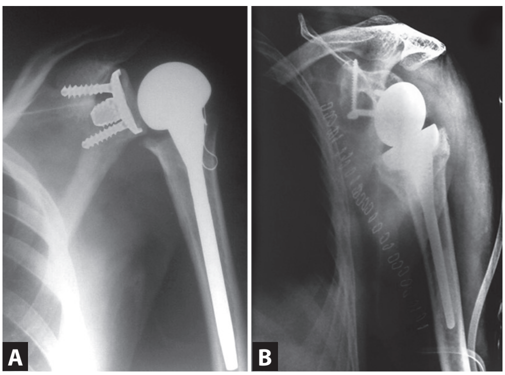


Fig. 35.3 X-ray: Total shoulder arthroplasty: (A) Conventional; (B) Reverse shoulder (*Courtesy:* Dr Anand Shankar)

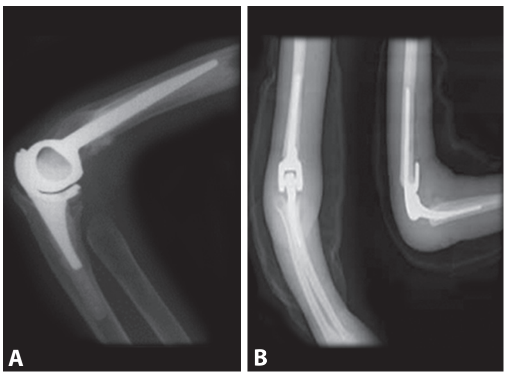
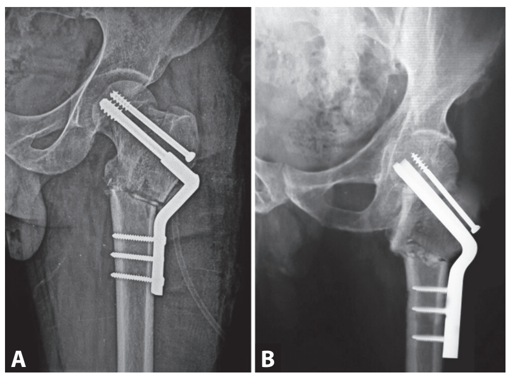


Fig. 35.4 X-ray elbow arthroplasty: (A) Unconstrained; (B) Semi-constrained (*Courtesy:* Dr Anand Shankar)

preserved capsuloligamentous support
- Semiconstrained (linked) implant-indicated in poor bone stock and damaged capsulo-ligamentous support.
- Incongruency of humeroulnar component in form of subluxation or dislocation in unconstrained prosthesis
- Implant loosening commonly of humeral component in semiconstrained prosthesis
- *Preoperative radiographic assessment:* Radiographic view: AP view and lateral view
- *Measurement like:* Humeroulnar axis: male 10°–15°, female 15°–20°
- *Indication of TEA:*
- End stage elbow arthritis following: trauma, infection both pyogenic or tubercular, degenerative, rheumatic disorder
- *Other indications:*
    - Ankylosis in poor functioning position
    - Low demanding elderly patient
- *Contraindication:* Contraindication for TSA.
    - Active or recent infection
    - Sever dysfunction of biceps and triceps
    - Flaccid paralysis of upper limb
    - Neuropathic elbow joint
    - High demanding and younger patient
- *Complication:*
    - *Chief complication:*
        - Infection
        - Joint stiffness and ankylosis
        - Instability (unconstrained implant in form of subluxation and dislocation)
    - *Soft tissue related complication:*
        - Nerve intrapment
        - Heterotopic ossification
        - Triceps problems
    - *Implant related complication:*
        - Implant loosening (semiconstrained implant due to polyethylene wear)
        - Periprosthetic fracture

X-RAY: VALGUS OSTEOTOMY PROXIMAL FEMUR (FIGS 35.5A AND B)

- *Radiographic description:*
    - *Bone and joint changes:*
        - Changes of osteoarthritis
        - Changes of avascular necrosis (AVN)
        - Status of union
    - *Implant:*
        - Double angle dynamic hip screw (DHS)
        - Double angle blade plate
- *Preoperative radiographic assessment:*
    - *Radiographic view:* AP view of pelvis showing both hip joint in 15° internal rotation
    - *Measurement like:*
        - Pauwel's angle,
        - Neck-shaft angle
        - Determination of wedge angle
- *Indication of osteotomy:* Commonly used in cases like:
    - Nonunion neck of femur
    - Malunited trochanteric fracture
    - Osteoarthritis of hip
- *Principle and method:*
    - *Principle:*



Figs 35.5A and B X-ray: Valgus osteotomy proximal femur fixed with: (A) Double angle DHS; (B) Double angle blade plate

- Shearing forces are converted into compressive forces (nonunion neck of femur)
- Reduction of shearing friction at hip joint by changing coxa vara into coxa valga (malunited intertrochanteric fracture)
- Unloading of weight bearing area (osteoarthritis hip)

– *Methods:* Trochanteric closed wedge osteotomy fixed with
  - Double angle DHS
  - Double angle blade plate

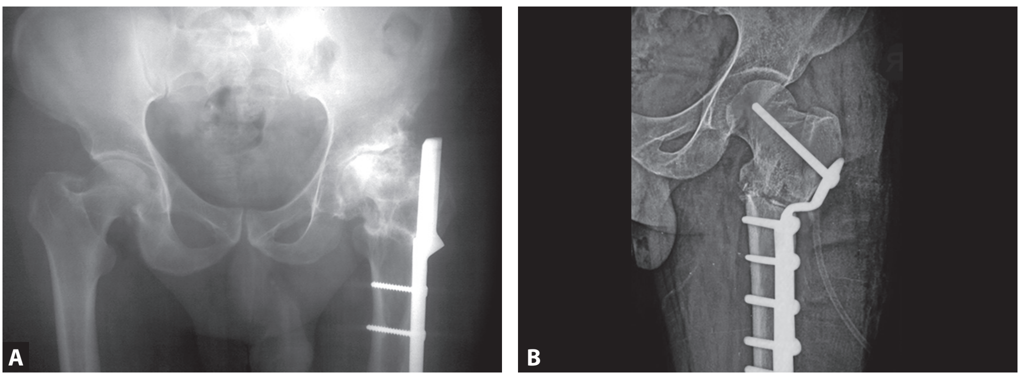
- *Complication:* Common complication are as:
  – Nonunion
  – Avascular necrosis of head
  – Varus collapse.

X-RAY: MEDIAL DISPLACEMENT OSTEOTOMY (FIGS 35.6A AND B)

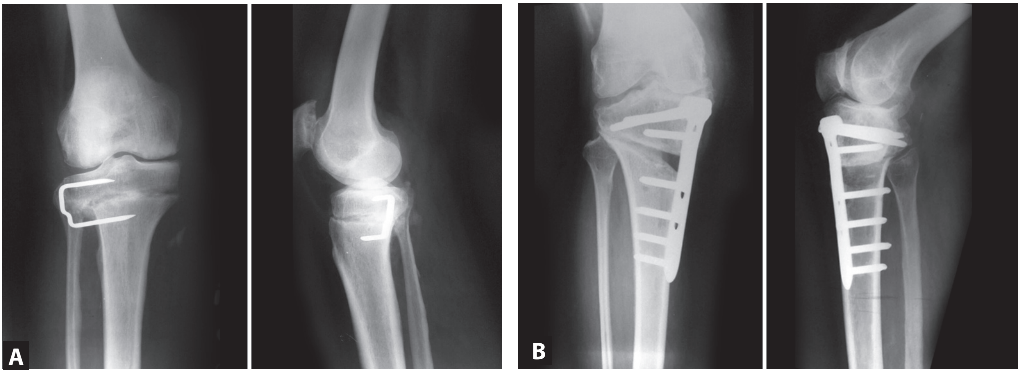
- *Radiographic description:*
  – *Bone and joint changes:*
    - Changes of osteoarthritis
    - Changes of AVN
    - Status of union
  – *Implant:*
    - Wainwright plate
    - Tupman plate
- *Preoperative radiographic assessment:*
  – *Radiographic view:*
    - AP view of pelvis showing both hip joint in 15° internal rotation
  – *Measurement like:*
    - Pauwel's angle
    - Neck-shaft angle
- *Indication of osteotomy:* Commonly used in cases like nonunion neck of femur
- *Principle and method:*
  – *Principle:* Arm-chair effect and direct weight transfer to shaft of femur
  – *Methods:* Oblique osteotomy at lesser trochanter level, medialization of distal segment and fixed with
    - Wainwright plate
    - Tupman plate
- *Complication:* Common complication are as:
  – Lurching
  – Nonunion.

X-RAY: PROXIMAL TIBIAL OSTEOTOMY (FIGS 35.7A AND B)

- *Radiographic description:*
  – *Bone and joint changes:*
    - Changes of osteoarthritis
    - Changes of osteonecrosis
    - Status of union at osteotomy site
  – *Implant:*
    - Coventry staple
    - T plates, TomoFix, Puddu plate
- *Preoperative radiographic assessment:*
  – Radiographic view—standing AP view extending from pelvis to ankle
    - Arthrogram
    - Scanogram



Figs 35.6A and B X-ray: Medial displacement osteotomy fixed with (A) Wain-wright plate; (B) Tupman plate (*Courtesy:* Dr Anand Shankar)



Figs 35.7A and B X-ray: Proximal tibial osteotomy fixed with (A) Coventary staple; (B) Tomofix (*Courtesy:* Dr Anand Shankar)

- *Look for:*
  - Bone stock
  - Anatomical axis, mechanical axis and vertical axis (Fig. 35.2B)
- *Indication and ideal candidate for osteotomy:*
  - Genu varus or valgus deformity due to tibia in skeletally mature young patient following. Trauma, infection, degenerative, inflammatory, metabolic or idiopathic causes
  - *Other indication are:*
    - Osteochondritis dissecans
    - Osteonecrosis
    - Posterolateral instability
    - Chondral resurfacing
- *Principle and method:*
  - *Principle:*
    - Correction of mechanical axis
    - Unloading of diseased cartilage and promoting repair process
  - *Osteotomy methods:*
    - Lateral closed wedge and medial open wedge osteotomy for varus
    - Lateral open wedge and medial closed wedge osteotomy for varus
    - Fixation with coventry staples or specially designed plates
    - Always do overcorrection of 3°–5°
    - Dealing with fibula in lateral closed wedge osteotomy as follows:
      - Disruption of superior tibio-fibuar joint
      - Excision of head
      - Osteotomy of fibular neck
      - Partial removal of inferomedial part of head and neck of fibula
- *Complication:* Common complication are as:
  - Common peroneal nerve palsy
  - Nonunion
  - Compartment syndrome.

X-RAY: EPIPHYSIODESIS AROUND KNEE (FIG. 35.8)

- *Radiographic description:*
  - Bone and joint changes—if any
  - Implant
- *Preoperative radiographic assessment:*
  - Radiographic view-same as above
  - *Look for:*
    - Bone stock
    - Anatomical axis, mechanical axis and vertical axis (Fig. 35.2)
- *Indication of epiphysiodesis:* Genu valgus or varus deformity due to tibia, femur or both in skeletally immature with sufficient time for growth modulation—the conditions may be.
  - Post-traumatic
  - Post infective
  - Metabolic
  - Idiopathic
- *Principle and method:*
  - *Principle:* Controlled growth arrest of physis to the side where epiphysiodesis

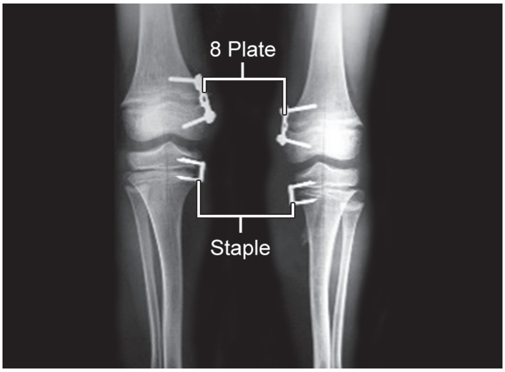


Fig. 35.8 X-ray: Epiphysiodesis around knee fixed with figure 8 plate and Blounts' staple

Fig. 35.9 X-ray: Hip arthrodesis with cobra plate

is done and normal growth continued towards the other side leading to deformity correction.

- *Methods:* Physeal closure is induced with help of
  - Blounts' staple
  - Figure 8 plate or small low profile plates and screw

- *Complication:* Common complication are as:
  - Back out of implant
  - Over correction of deformity
  - Under correction of deformity
  - New deformity like recurvatum or procurvatum.

X-RAY: HIP ARTHRODESIS (FIG. 35.9)

- *Radiographic description:*
  - *Bone and joint status:*
    - Ankylosis of joint
    - Pseudoarthrosis
  - *Arthrodesis method and Implant description:*
    - Arthrodesis with multiple cancellous screw—**Benaroch et al**.
    - Arthrodesis with DHS—**Pagnano and Cabanela**
    - Arthrodesis with Cobra plate—**Steidner**
    - Extra-articular arthrodesis with screw—Iliofemoral (**Hibb's** procedure) and Ischiofemoral (**Brittain's** procedure).
    - *Arthrodesis in absence of femur head:*
      - Fusion of joint in wide abduction followed by subtrochanteric osteotomy (**Abott** and **Fisch** method)
      - Femoro-ischial arthrodesis (**Bosworth's** technique)
- *Ideal position for arthrodesis is:*
  - Hip flexion—25°–30°
  - Hip abduction—neutral
  - Hip external rotation—0–5°
- *Indication and candidate for arthrodesis:*
  - *The important indications are:*
    - *Severe arthritis:* Traumatic, infective (pyogenic or tuberculosis)
    - *Painful ankylosis:* Traumatic, infective
    - *Severe deformity:* Traumatic, infective, paralytic (polio)
    - *Hip instability:* Traumatic, infective, following tumor resection around hip, neuroparalytic disorder
    - Failed total hip arthroplasty
  - Best candidate are young individual (age preferably less than 40 years) with good bone quality
- *Contraindication:* Common contraindication are as:
  - Active hip infection (absolute)

- Diseased contralateral hip and ipsilateral knee
- Degenerative spine disorder
- *Complication:* Chief complication are:
  - Limb length discrepancy
  - Pseudoarthrosis
  - Abnormal alignment of limb
  - Strain over spine and ipsilateral knee and contralateral hip.

X-RAY: KNEE ARTHRODESIS (FIG. 35.10)

- *Radiographic description:*
  - *Bone and joint status:*
    - Ankylosis of joint
    - Pseudoarthrosis
  - *Arthrodesis method and implant description:*
    - *Arthrodesis with nail:* Long interlocking nails
    - *Arthrodesis with plates:*
      - Single plating
      - Double plating
    - *Arthrodesis with external fixator:* Compression arthrodesis
      - Unilateral biplanar or bilateral uniplanar AO fixator
      - **Charnley** clamp method
      - **Ilizarov** method
- *Ideal position for arthrodesis is:*
  - *Knee flexion:* 0°–15°
  - *Knee valgus:* 5°–8°
  - *Knee external rotation:* 10°
- *Indication and candidate for arthrodesis:*
  - *The important indications are:*
    - *Severe arthritis:* Traumatic, infective, osteochondritic
    - *Painful ankylosis:* Traumatic, infective
    - *Severe deformity:* Traumatic, infective, metabolic, paralytic
    - *Knee instability:* Traumatic, infective, following tumor resection around knee, charcot arthropathy
    - Failed total knee arthroplasty
  - Best candidate are young individual with heavy weight and hard activity (e.g. laborer) with good bone stock

Fig. 35.10 X-ray: Knee arthrodesis with long interlocking nail

- *Contraindication:* The main contraindication is
  - Ipsilateral hip and contralateral knee disease
- *Complication:* Chief complication are:
  - Limb length discrepancy
  - Pseudoarthrosis
  - Abnormal alignment of limb
  - Strain over spine and ipsilateral hip and ankle.

X-RAY: ANKLE ARTHRODESIS (FIG. 35.11)

- *Radiographic description:*
  - *Bone and joint status:*
    - Ankylosis of joint
    - Pseudoarthrosis
  - *Arthrodesis method and implant description:*
    - *Arthrodesis with multiple cancellous screw:*
      - Tibiotalar screw fixation **(Moekel et al.)**
      - Talotibial screw fixation (**Mann et al.)**
    - *Tibiocalcaneal arthrodesis:* Fixed with intramedullary nail
    - *Arthrodesis with external fixator:* Compression arthrodesis
      - **Calandruccio** clamp or **Charnley's** clamp method

- **Ilizarov** method
- **Stewart** and **Harley** arthrodesis—narrowing of malleoli
  - Arthrodesis in talar osteonecrosis:
    - Tibiotalar-calcaneal arthrodesis with bone graft and fixed with intramedullary nail or posterior locking plate (**Campbell** procedure)
    - Tibiotalar arthrodesis with sliding bone graft fixed with a cancellous screw (**Blair's** procedure)
- *Ideal position for arthrodesis is:*
  - Plantar flexion and dorsiflexion—neutral
  - Valgus—5°
  - External rotation—5°.

***Mann's** principle for ankle arthrodesis:*
Broad, flat, cancellous surface area for apposing surfaces for fusion.
Stabilization of arthrodesis site with rigid internal or external fixation.
Alignment of forefoot, hind foot and leg to form a plantigrade foot.

- *Indication and candidate for arthrodesis:*
  - The important indications are:
    - *Severe arthritis:* Traumatic, infective, inflammatory
    - *Painful ankylosis:* Traumatic, infective
    - *Severe deformity:* Traumatic, infective, metabolic, paralytic

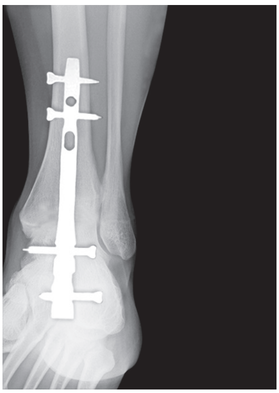


Fig. 35.11 X-ray: Ankle arthrodesis with PFN

    - *Knee instability:* Traumatic, infective, following tumor resection around ankle, charcot arthropathy
    - Failed total ankle arthroplasty.
  - The best candidate are young individual doing heavy activity with good bone quality
- *Contraindication:* As such no containdication
- *Complication:* Chief complication are:
  - Limb length discrepancy
  - Pseudoarthrosis
  - Abnormal alignment of limb
  - Strain over spine and ipsilateral hip and ankle.

X-RAY: SHOULDER ARTHRODESIS (FIG. 35.12)

- *Radiographic description:*
  - *Bone and joint status:*
    - Ankylosis of joint
    - Pseudoarthrosis
  - *Method and implant description:*
    - Arthrodesis with multiple screw—**Cofield**
    - *Arthrodesis with plates:*
      - With AO plates—**Muller et al**.
      - With pelvic reconstruction plate—**Richard et al**.
    - Arthrodesis with external fixator—**Charnley and Houston**.
    - Arthrodesis in absence of humeral head—with bone graft and reconstruction plate: **Scalise and Iannoti**
- *Ideal position for arthrodesis is:*
  - *Shoulder flexion:* 10°–20°
  - *Shoulder abduction:* 10°–20°
  - *Shoulder internal rotation:* 35°–45°
- *Indication and candidate for arthrodesis:*
  - *The important indications are:*
    - *Severe arthritis:* Traumatic, infective, inflammatory, rotator cuff arthropathy
    - *Painful ankylosis:* Traumatic, infective
    - *Severe deformity:* Traumatic, infective, paralytic

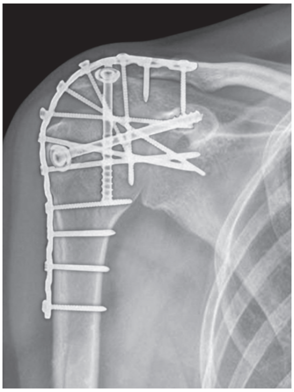


Fig. 35.12 X-ray: Shoulder arthrodesis with reconstruction plate and screw

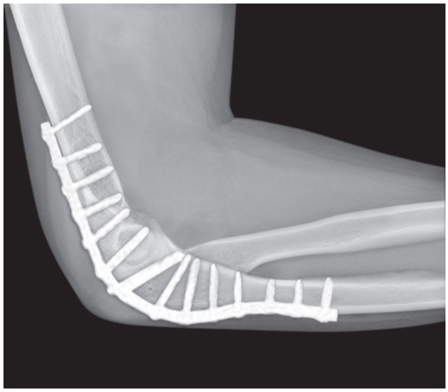


Fig. 35.13 X-ray: Elbow arthrodesis with plate and screw

    - *Shoulder instability:* Traumatic, atraumatic, following tumor resection around shoulder, deltoid and rotator cuff insufficiency.
    - Impossible or failed shoulder arthroplasty, charcot arthropaty
  - The candidate for arthrodesis must have normal scapulothoractic rhythm and good bone stock.
- *Contraindication:* Common contraindication are as:
  - Paralysis of pectoral girdle movers like trapezius, levator scapulae, serratus anterior, rhomboids
  - Ipsilateral elbow and contralateral shoulder fusion
  - Poor forearm and hand function
- *Complication:* Chief complication are:
  - Infection and wound dehiscence
  - pseudoarthrosis
  - Hardware complication
  - Strain over AC joint and periscapular muscle
  - Humerus fracture
  - Traction neuritis.

X-RAY: ELBOW ARTHRODESIS (FIG. 35.13)

- *Radiographic description:*
  - *Bone and joint status:*
    - Ankylosis of joint
    - Pseudoarthrosis
  - *Arthrodesis method and implant description:*
    - *Arthrodesis with plate:* By **Spier**
    - *Arthrodesis with bone graft and screw:* **Staples**
    - *Arthrodesis with external and internal fixation:* **Muller et al**.
    - *Arthrodesis with bone graft in X manner:* **Brittain's** technique.
- *Ideal position for arthrodesis:*
  - *In unilateral cases arthrodesis at:* 90°–100° flexion and mid-prone position
  - *In bilateral cases:*
    - Arthrodesis at 110°–120° elbow flexion and mid-prone for eating
    - Arthrodesis at 45°–65° elbow flexion and supination for hygine
- *Indication and candidate for arthrodesis:*
  - *The important indications are:*
    - *Severe arthritis:* Traumatic, infective, inflammatory
    - *Painful ankylosis:* Traumatic, infective
    - *Severe deformity:* Traumatic, infective, paralytic
    - *Shoulder instability:* Traumatic, atraumatic, following tumor resection around shoulder, charcot arthropathy
    - Impossible or failed elbow arthroplasty
  - The candidate must have good bone stock for successful elbow fusion.
- *Contraindication*: Contraindication for elbow arthrodesis is—ipsilateral shoulder fusion

- *Complication:* Chief complication are:
  - Infection
  - Wound dehiscence
  - Hardware related complication
  - Malunion
  - Nonunion.

X-RAY: WRIST ARTHRODESIS (FIG. 35.14)

Fig. 35.14 X-ray: Wrist arthrodesis with plate and screw

- *Radiographic description:*
  - *Bone and joint status:*
    - Ankylosis of joint
    - Pseudoarthrosis
  - *Osteotomy method and implant description:* Arthrodesis with plate:
    - *Plating in dorsal slot and bone grafting:* **Haddad** and **Riordan**
    - *Pre-contoured plating with bone grafting:* **Weiss** and **Hasting**.
- *Ideal position for arthrodesis is:*
  - *Unilateral cases arthrodesis at:* Clenched fist position, 10°–20° dorsi flexion and 3rd metacarpal in line of radius.
  - *In bilateral cases:* Neutral wrist position
- *Indication and prerequisite for arthrodesis:*
  - *The important indications are:*
    - *Severe arthritis:* Traumatic, infective, inflammatory
    - *Painful ankylosis:* Traumatic, infective
    - *Severe deformity:* Traumatic, infective, paralytic, VI contracture
    - *Wrist instability:* Traumatic, atraumatic, following tumor resection around wrist, charcot arthropathy, post polio residual paralysis, hemiplegia
    - Impossible or failed wrist arthroplasty
  - The candidate must have good bone stock for successful wrist fusion.
- *Contraindication:*
  - As such no contraindication for arthrodesis is—
- *Complication:* Chief complication are:
  - Wound infection
  - Wound dehiscence
  - Hardware related complication
  - Nonunion
  - Metacarpophalangeal joint stiffness
  - Sympathetic dystrophy
  - Carpal tunnel syndrome
  - Distal radioulnar joint instability.

SECTION 4

Table of Orthosis and Prosthesis

Upendra Kumar

Chapters

PICKING OF ORTHOSIS AND PROSTHESIS

- *Proceeding on orthosis and prosthesis table:*
  - You may ask to pick a orthosis or prosthesis or both.
  - Examiner himself may give you either orthosis or prosthesis.
- *Examiners expectation in this section:*
  - Name of orthosis or prosthesis
  - Parts of orthosis or prosthesis
  - Regional classification of orthosis and prosthesis and their function
  - Indication for wearing of orthosis or prosthesis
  - Care of limb fitted with orthosis or prosthesis

CHAPTER

36

Basics about Orthosis

Orthotics play a crucial role in orthopedic and neurological rehabilitation. It ranges from simplest finger ring to most cumbersome calipers.

DEFINITION

An orthosis is a orthopedic appliance used to modify the structural and function characteristics of body parts.

FUNCTIONS

- To control, limit and guide an extremity or joints
- To correct deformity of body or body parts
- To assist weak segment
- To enforce specific directional control
- To keep the segments in functional position.

CLASSIFICATION (ANATOMICAL BASIS)

- *Lower limb:*
  - Hip knee ankle foot orthosis (HKAFO)
  - Knee ankle foot orthosis (KAFO)
  - Ankle foot orthosis (AFO)
  - Foot orthosis (FO)
- *Upper limb:*
  - Shoulder orthosis (SO)
  - Elbow wrist hand orthosis (EWHO)
  - Wrist hand orthosis (WHO)
  - Hand orthosis (HO)
- *Spine:*
  - Cervical orthosis (CO)
  - Cervico-thoraco-lumbo-sacral orthosis (CTLSO)
  - Thoraco-lumbo-sacral orthosis (TLSO)
  - Lumbo-sacral orthosis (LSO).

CLASSIFICATION (MECHANICAL BASIS) (FIGS 36.1A AND B)

- *Dynamic orthosis:* These splints have some mobile unit and allows movement to splinted part (Fig. 36.1A).
- *Static orthosis:* These splints have neither any mobile unit nor allows any motion to splinted part (Fig. 36.1B).

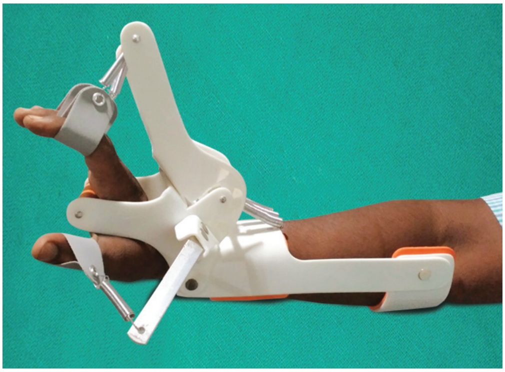


Fig. 36.1A Dynamic orthosis

Fig. 36.1B Static orthosis

MATERIAL

- Metal stripes and sheet
- *Plastic:* Two type
  1. *Thermosoftening or thermoplastic:* A plastic material that becomes pliable on heating and hardened on cooling, e.g. PVC (polyvinyl chloride)
  2. *Thermosetting plastic:* A plastic material that irreversibly becomes hard when heated, e.g. fiberglass
- Leather
- Foam
- Various type of fabrics
- Velcro strap

CRITERIA OF A GOOD ORTHOSIS

- One who fulfill its function
- Light weight
- Compliance to the patient
- Proper fitting to limb
- Cosmetically acceptable.

COMPLICATIONS

- Atrophy of the part
- Neurovascular compromise
- Joint stiffness
- Skin complication.

CHAPTER

37

Lower Limb Orthosis

FOOT ORTHOSIS

- *Surgical shoe: (Fig. 37.1)*
  - *Components of surgical shoe:*
    - Toe box
    - *Upper:* Vamp (anterior), quarter (posterior) and throat
    - *Sole:* Insole and outsole
    - Counter
    - Heel
- *Shoe modifications:*
  - Purpose of shoe modification
    - Restoration of normal gait pattern
    - For proper distribution of body weight over foot
    - For balancing when person is standing
    - As a component of caliper.
  - *Common external shoe modification (Figs 37.2A to E):*
    - *Shoe wedging:* The medial wedge or lateral wedge increases the pronation or supination of foot respectively, e.g. used for genu valgum (medial wedge) or genu varum (lateral wedge) correction.
    - *Heel flare:* This is medial-lateral extension of heel to increase the stability of foot. It also resist inversion (lateral flare) or eversion (medial flare) of foot and side by side increases the activity of opposite muscle, e.g. ankle lateral or medial ligaments injury.

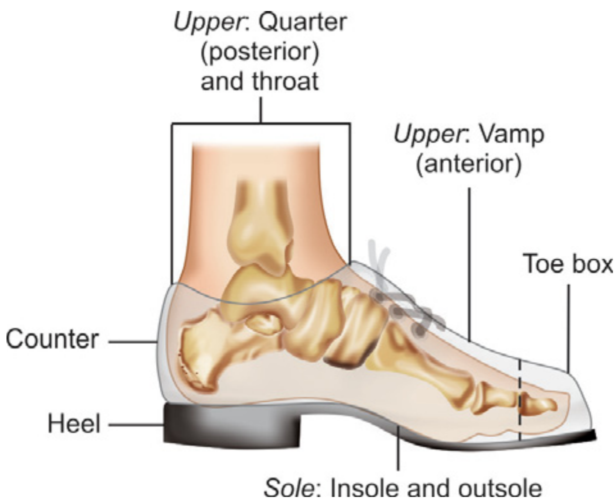
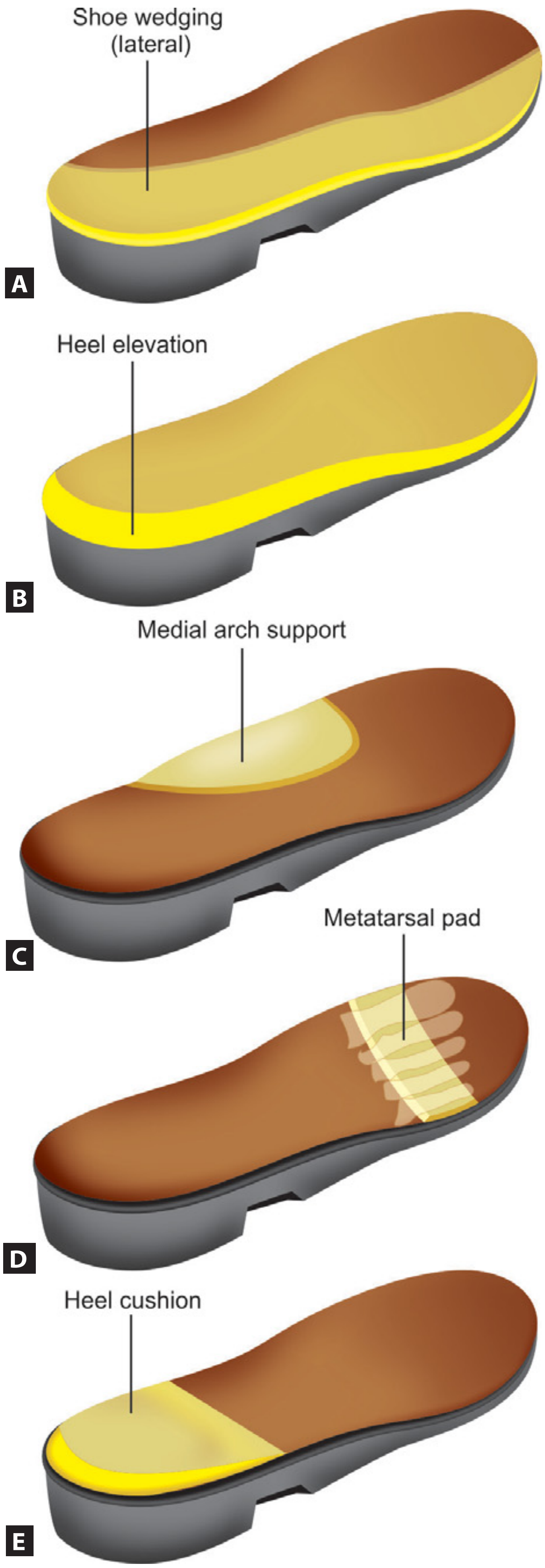


Fig. 37.1 Components of a surgical shoe

- *Heel elevation:* This increases the height of heel, e.g. used for compensation of fixed equines deformity. The combined heel and sole elevation can be used for compensation of limb-length discrepancy.
- *Thomas heel:* It is 1 cm extension of medial aspect of heel for support of medial longitudinal arch, e.g. used for flat foot.
- *Metatarsal bar:* It transfers the load from metatarsals head to metatarsal shaft area, e.g. used for metatarsalgia.

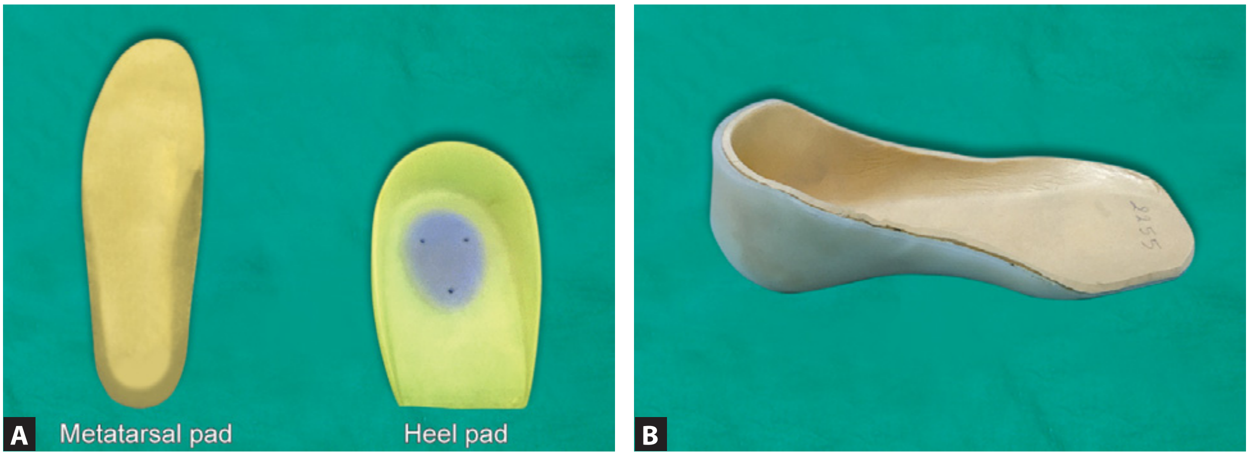
Figs 37.2A to E Common external shoe modifications



Figs 37.3A to E Commom internal shoe modifications

– *Common internal shoe modification: (Figs 37.3A to E)*
  - *Shoe wedging:* It acts on the same principle of external shoe wedging but the wedge shaped pad is fitted in the inner sole of shoe.
  - *Heel elevation:* This is a internal counterpart of external shoe modification. This is used for fixed equinus deformity and limb length discrepancy.
  - *Medial arch support:* Here a wedge of rubber or plastic foam is fitted in the in-sole of shoe against medial longitudinal arch of foot, e.g. used in flat foot.
  - *Metatarsal pad:* A spongy rubber pad is fitted in inner sole of shoe against the ball of metatarsals, e.g. used for metatarsalgia.
  - *Heel cushion:* Here a soft compressible foam is fitted in inner aspect heel of shoe, e.g. used for inferior heel pain.

- *Shoe inserts:* These may be accommodative or corrective: (Figs 37.4A and B)
  – *Soft inserts:* These are made up of foam polyethylene or foam rubber, e.g. heel pad, sole pad, metatarsal pad, etc.
  – *Rigid inserts:* These are mainly composed of thermoplastic, e.g. University of California Biomechanics Laboratory (UCBL) insert: it keeps the calcaneum in proper position with help of its three (medial, lateral and posterior) walled design.
- *Foot orthosis: (Figs 37.5A and B)*
  – It may be dynamic or static.
  – Components of orthosis: It is made up metal sheets, thermoplastic, fabrics, rubber, silicon, etc.
    - Foot piece and toe piece
    - Straps
  – *Function:*
    - It immobilizes the metatarso-phalangeal joint and interphalangeal joint.



Figs 37.4A and B Shoe inserts: (A) Soft inserts; (B) Rigid inserts (UCBL)

Figs 37.5A and B Foot orthosis: (A) Hallux valgus and varus correcting orthosis; (B) Rings splint for hammer toe correction

  - It corrects deformity at metatarsophalangeal (MTP) and interphalangeal joints.
- Common foot orthoses are:
  - *Hallux valgus and varus correcting orthosis:* It acts on the principle of three point pressure and ensures a inward or outward force over great toe to correct the hallux valgus or hallux varus deformity respectively.
  - *Rings or splints for toes deformity correction:* It also acts on the principle of three point pressure are used for following toes deformities.

	Hammer toe (2nd toe)	*Claw toe*
Metatarsophalangeal (MTP) joints status	Usually hyperextended	Hyperextended
Proximal interphalangeal (PIP) joint status	Flexed	Flexion
Distal interphalangeal (DIP) joint status	Flexion or extension	Flexion

ANKLE-FOOT ORTHOSIS DESIGN

Conventional Type Ankle-Foot Orthosis (AFO) (Fig. 37.6A)

- *Components are as:*
  - Surgical shoe with stirrup
  - Ankle joint
  - Metal uprights
  - Calf band
  - Strap.
- *Functions of AFO:*
  - Support the ankle and foot, e.g. foot drop
  - To maintain ankle stability, e.g. post-polio residual deformity, neuropathic feet
  - To prevent equinus contracture, e.g. Ilizarov worn over leg.

Fig. 37.6A Conventional type AFO

Fig. 37.6B Total contact AFO

Total Contact AFO (Fig. 37.6B)

- These are thermoplastic made AFO which is molded over negative of plaster of Paris leg-foot cast
- It may articulating or nonarticulating type as per ankle joint
- Floor reaction orthosis is a special type of total contact AFO.

Floor Reaction AFO (Fig. 37.6C)

- *Principle:* Newton's third law of motion
- *Fabrication:*
  - Total contact type made up of rigid polypropylene or carbon-fiber

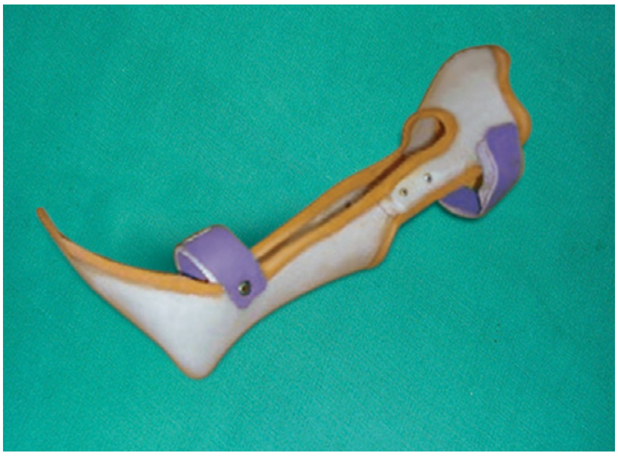


Fig. 37.6C Floor reaction AFO

- Foot piece of orthosis is set in 3–5° of plantar flexion
- Proximal or posterior entry designs.

- *How it works:*
  - It holds ankle in equinus to prevent the heel from touching the ground and as the body weight brings the heel downwards, the suprapatellar band presses the knee backward and check the buckling of knee during stance phase.
  - It allows the knee to flex during swing phase when the foot is off the ground.
- *Prerequisite:* Healthy and fair functioning quadriceps.

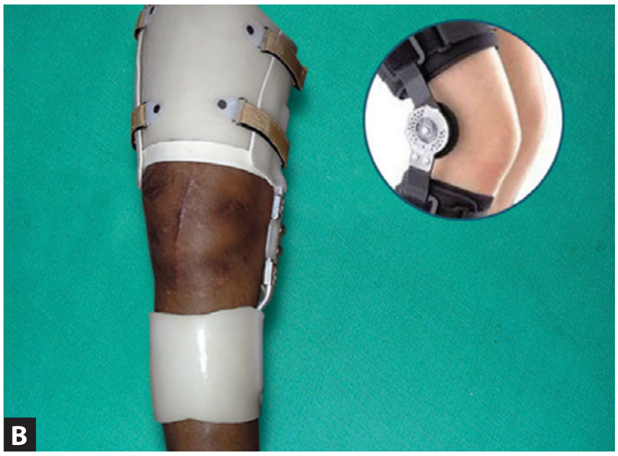
KNEE ORTHOSIS AND KNEE JOINTS IN LOWER LIMB ORTHOSIS (FIGS 37.7A TO F)

Common Knee Orthoses

Knee Immobilizers

- This splint extends from mid thigh to mid leg.
- Components
  - Made up of light metal and canvas
  - Straps
- Function and uses
  - It maintain the knee in extension position.
  - A multiple purposes splints useful in sprain and strain and many postoperative conditions around knee.

Knee immobilizers



Knee range of motion (ROM)

Mermaid splint

Figs 37.7A to C

Valgum-varus brace

Swedish knee cage

Knee gaiter

Figs 37.7D to F Knee orthosis

Knee Range of Motion (ROM)

- Commonly used splint.
- Components-made up of metal and polypropylene sheets.
  - Thigh piece and leg piece
  - Knee joint
  - Straps
- *Function and uses:*
  - It provides protected and controlled knee motion.
  - Used for various conditions like peri-articular fracture fixation, ligamentous reconstruction etc.

Valgum-Varus Brace

- This orthosis is getting much honor nowadays.
- Components-made up of light metal and canvas.
  - Thigh piece and leg piece
  - Knee joint
  - Straps
- Function and uses:
  - It acts on the principle of three points pressure.
  - Used for deformity correction like knock-knee, bow leg, tibia-vara or degenerative and inflammatory arthritis related axial deformity.

Swedish Knee Cage

It is a nonarticular orthosis made up of light metal strips and polypropylene sheets. It acts on the theory of three point pressure and keeps the knee in extension position and gradually corrects the recurvatum deformity of knee.

Mermaid Splint

It is a nonarticular orthosis which keeps the both knee solidly in the night with help of two conjoined polypropylene sheet and straps. Splint is very useful when disease is in active phase and deformity is mild. As it recalls the shape of a mermaid (jalpari), i.e. why it is called mermaid splint.

Knee Gaiter

It is also nonarticular orthosis made up of canvas and rigid metal strips which maintains the knee in extension position. This is commonly used in spastic knee like cerebral palsy cases.

Commonly Used Knee Joints in Lower Limb Orthoses (Fig. 37.8)

- *Single axis knee joint:*
  - Free flexion-extension is possible at knee joint
  - There is restriction for hyperextension
  - Joint is provided with drop lock
  - Drop-lock is pulled for unlocking of knee joint leading to knee flexion
  - A variant of single axis knee joint is posterior offset type where hyperextension of knee joint is restricted by a posteriorly placed offset not by drop-lock.
- *Stance control knee joint:*
  - No knee flexion possible when joint is subjected to weight bearing.
  - Free flexion-extension possible only when knee joint is unweighted.
  - Used for knee extensor paralysis or paresis.
- *Polycentric knee joint:*
  - It is said to be closer to the anatomic knee joint.
  - There is a pistoning effect at orthotic knee joint during gait cycle which is reduced by polycentric knee joint.
  - Commonly used in sports orthotics.
- *Lock in variable flexion type knee joint:*
  - There is removable hold in sagittal plane which function in full extension during stance and swing phase of the gait.
  - Can be released for flexion during sitting;
  - Integral adjustment for extension stop.

KNEE-ANKLE-FOOT ORTHOSIS (FIGS 37.9A TO C)

Conventional Knee-Ankle-Foot Orthosis (KAFO)

- *The components of (conventional type) include:*
  - Surgical shoes
  - Ankle joint and stirrup assembly
  - Metal uprights

Single axis knee joint (drop lock and posterior offset)

Stance control knee joint

Polycentric knee joint

Lock in variable flexion type knee joint

Fig. 37.8 Commonly used knee joints in lower limb orthoses

Fig. 37.9A Conventional KAFO

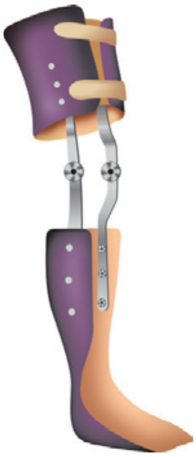


Fig. 37.9B Total contact KAFO

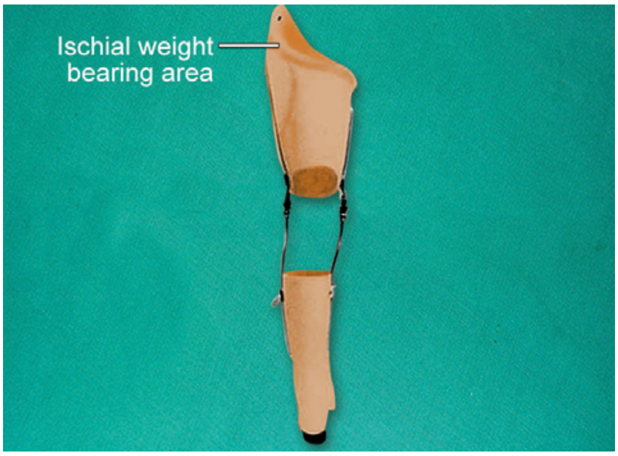


Fig. 37.9C Ischial weight bearing type KAFO

- Knee joint
- Calf and thigh bands
- Straps and paddings

- *Function of KAFO:*
  - Prevent buckling of knee and facilitate ambulation., e.g. postpolio residual paralysis.
  - Maintain stability of knee, e.g. neuropathic joint
  - To relieve weight on bone and joint of lower limb.

Total Contact KAFO

- These are made up of thermoplastics attached with knee joint.
- *Ischial weight bearing type KAFO:* A variant of total contact KAFO
  - Here the body weight is transferred from ischium to the orthosis and relieve the distal part of limb.
  - A quadrilateral socket (as in above knee prosthesis) is used to support the ischium and buttock.

☑ *Note:* Patellar tendon bearing (PTB) type KAFO is also prevalent nowadays. Here body weight is transferred from patellar tendon and tibial condyle to orthosis and relieve the distal part of limb. A PTB type socket (as in below knee BK prosthesis) is used to hold the patellar tendon and tibial condyle.

HIP-KNEE-ANKLE-ORTHOSIS (FIGS 37.10A AND B)

Conventional Type Hip-Knee-Ankle (HKAFO)

- *The components of (conventional type) include:*
  - Surgical shoes
  - Ankle joint with stirrup assembly
  - Metal uprights
  - Knee and hip joints
  - Knee cap, calf band, thigh band and pelvic band
  - Strap/paddings
- *Function of HKAFO:*
  - Maintain standing posture of person and ensure the mobility.
  - Maintain stability of hip joint.

Fig. 37.10A Conventional type HKAFO

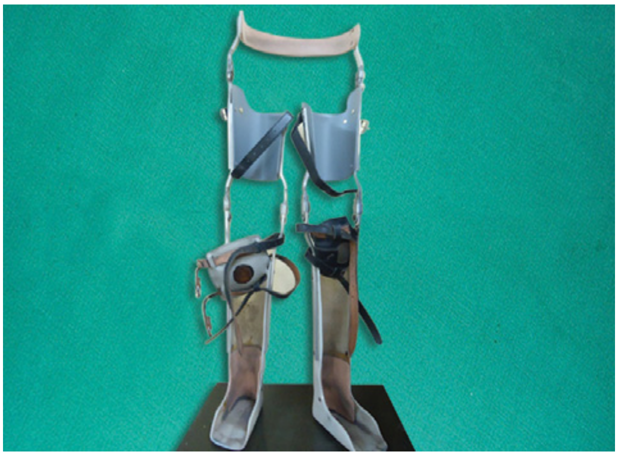


Fig. 37.10B Reciprocating gait orthosis [*Courtesy:* Sant Prakash Gautam MPO (NIOH), Kolkata]

Total Contact HKAFO

- These are fabricated with thermoplastics attached with hip and knee joints
- *A variant of total contact HKAFO: Reciprocating gait orthosis (RGO): a special HKAFO*
  - Commonly used in cases of spina bifida and spinal cord injury
  - Combines flexion of one hip with extension of the opposite hip
  - The flexion power of one hip is utilized to extend the opposite hip.

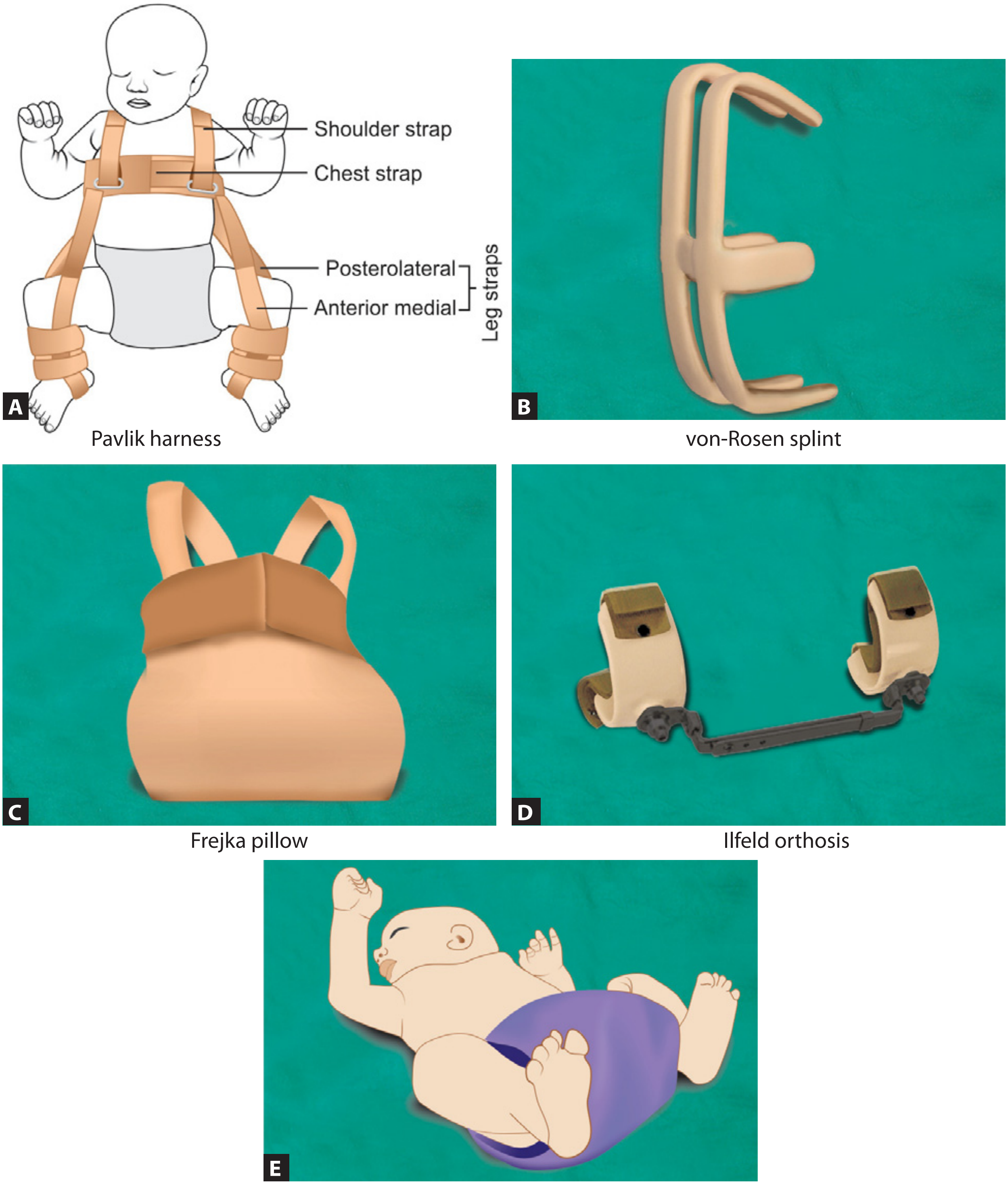
SPECIAL ORTHOSIS FOR LOWER LIMB (FIGS 37.11A TO E)

Orthoses for DDH

- Pavlik harness
- von-Rosen splint
- Frejka pillow
- Ilfeld orthosis
- Tripple diaper

Pavlik Harness

- Dynamic flexion—abduction orthosis used to treat DDH in children up to 6 months of age
- *Parts of orthosis:*
  - *Chest strap 1:* As loose as 3 fingers could insinuate
  - Shoulder strap 2
  - *Leg strap 2:* Anteromedial (AM) for flexion control and posterolateral (AL) for abduction control.
- *How to wear:* Steps are as:
  - Lie the child in supine position
  - Chest strap at the level of nipple
  - Fix shoulder strap with chest strap
  - Hip is flexed to 90°–100° and apply AM stirrup.
  - Now wear the AL leg stirrup without any forceful abduction.
- *Checking of orthosis:*
  - Adduction test: The abduction at hip is maintained so much so that on adduction; the distance between both knee remain 3–5 cm not more.
  - *Stability test:* Do the Barlow's test
  - *Radiology:* To ensure the femoral neck in the direction of triradiate cartilage.
  - *If any dislocation:*
    - Superior—increase flexion
    - Inferior—decrease flexion
    - Lateral—observe for femoral neck direction
    - Posterior—orthosis unsuccessful
- *Follow-up:*
  - One visit at interval of 2 weeks—for stability test



A Pavlik harness; B von-Rosen splint; C Frejka pillow; D Ilfeld orthosis; E Triple diaper

Figs 37.11A to E Orthoses for DDH

- No more use of orthosis for any persistent sublaxation after 3–6 weeks of wearing.

- *Wearing schedule and weaning of orthosis:*
  - 2 hours daily for 2–4 weeks

- Doubling of wearing time forte weekly or monthly till night wearing comes
- Maximum period of wearing—up to the age when stability is obtained (normal radiology) + 2 months.

- *Risk factor for failure of harness:*
  - Dislocated hip
  - Bilateral cases
  - Treatment delayed beyond 6–7 weeks
  - Children at walking age
  - Spastic or paralytic limb
  - Femoral palsy during treatment
  - Initial coverage of head less than 20% under ultrasonography.

Orthoses for Perthes Disease (Figs 37.12A to D)

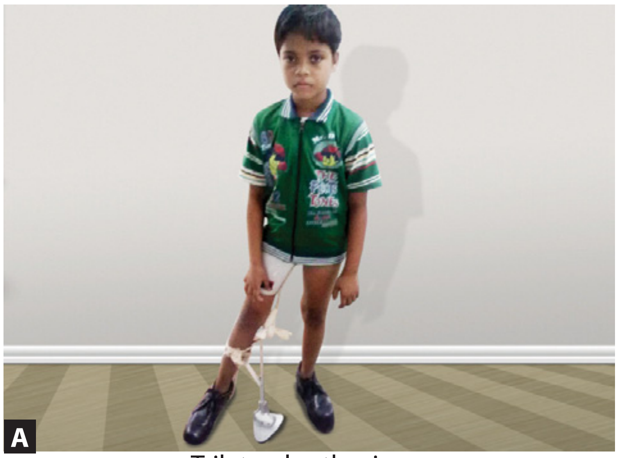
- Trilateral orthosis
- Toronto orthosis
- Newington orthosis
- Scottish rite orthosis

Trilateral Orthosis

- It is weight relieving hip abduction orthosis
- It is ischial weight bearing type KAFO that maintain the hip in 30° abduction
- Orthosis is fitted with a separate rubber walking heel that bear the weight on affected side during walking.

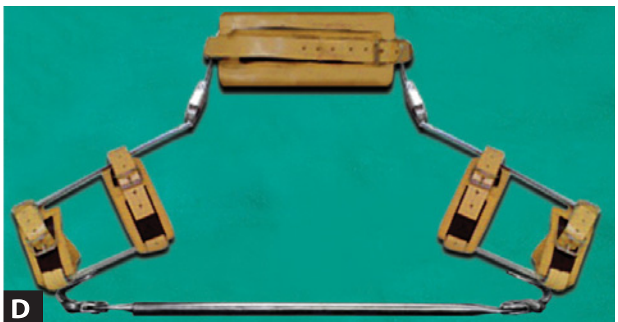
Turn Buckle Splint (Fig. 37.13)

- It is a dynamic splint.
- *Components of orthosis:* Thermoplastics is main constituent.
  - Thigh and leg piece
  - Joint support (for knee or ankle)
  - Metallic turn buckle system.
- *Function:* It produces gradual stretching over contracted joint by its turn-buckle mechanism, e.g.
  - Stiff knee
  - Equinus contracture.
- *Advantages:*
  - Corrects contracture of soft tissue very fast
  - Decreases rehabilitation time
  - Minimum atrophy of limb
  - Excellent patients' compliance


A Trilateral orthosis


B Toronto orthosis


C Newington orthosis


D Scottish rite orthosis

Figs 37.12A to D Abduction orthoses for perthes disease

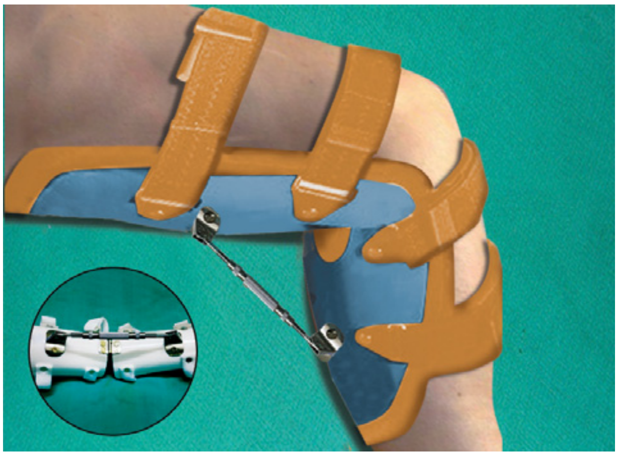


Fig. 37.13 Turn buckle splint

Orthoses for Congenital Talipes Equinovarus (CTEV) (Figs 37.14A to D)

- AFO
- CTEV shoe
- Dennis-Brown splint
- Steinbeck foot abduction brace

AFO for CTEV

- *Component:*
  - Total contact type AFO
  - Leg strap, ankle strap and lateral abduction strap
- Not very common.

CTEV Shoe

- *Characteristic of CTEV shoe are as:*
  - No heel
  - Straight medial border
  - Lateral sole wedge

Dennis-Browne Splint

- This device is named after Australian borne Dr John Dennis Wolko Browne working in London (1934).
- *Components and function:*
  - Curved bar (equal to width of shoulders) to maintain dorsiflexion at ankle
  - Pair of CTEV shoes attached at ends of bar

AFO for CTEV

CTEV shoe

Dennis-Browne splint

Steinbeck foot abduction brace

Figs 37.14A to D Orthoses for CTEV

- Winged nuts to allow abduction of each foot
- Commonly used in night.

Steinbeck Foot Abduction Brace

- Designed in Uganda by **Michael Steinbeck** and endorsed by *Dr* **Ponsetti**. This is effective and low cost option for developing countries.
- Where it is needed?
  - During ponsetti corrective casting treatment for club foot when deformity is corrected.
  - Deformity is said to be corrected when dorsiflexion 10°–15° and abduction 60°–70° is possible.
- *Why it is needed?*
  - To prevent recurrence of deformity. Failure of bracing is the most common cause of recurrence.
  - The deformity which recurs first is varus in congenital cases and equines in acquired cases.
- *Components of brace:*
  - Metallic bar
  - Open mouth strapped shoes with window over heel for inspection
  - Heel cup
- *Important dimensions:*
  - Maintain 10°–20° dorsiflexion by bent bar.
  - Heel cup to keep the heel firmly in the shoe
  - Maintain 70°of abduction at affected foot and 40° at unaffected side
  - Metallic bar as wide as shoulder of child (some add 2 cm with shoulder width).
- How and when to wear?
  - Immediately after removal of last cast. Why?... To increase the shoe acceptance.
  - Twenty-third hours a day for first 3 months after casting and remaining 1 hour for manipulation of foot.
  - Then in night only till the child is of 4 years (4th birthday)..to achieve sufficient maturation.
- *Attention during shoe wearing:*
  - First insert the more difficult foot in shoe.
  - Maintain dorsiflexion during shoe insertion.
  - Hardly any movement of foot will accepted inside the shoe: snugly fit.
  - Heel should be visible through inspection window of shoe.
- *Brace review schedule:*
  - First review at 3 weeks after issuing of brace
  - Then every 5 weeks till 1 year of age
  - Then every 3 months till 1.5 years of age
  - Then every 6 months till 4 years of age
- *What to look at follow-up:*
  - *Condition of brace:* Check all dimensions
  - Ask about any problem during wearing of shoe
  - Enquire about duration of daily wearing of shoe
  - *Check for any recurrence of corrected deformity:* Pirani scoring.
  - Check that foot has not overgrown the brace.

Difference between DB splint and Steinbeck FAB

Point	*DB splint*	*Steinbeck brace*
Cost	Costlier	Cheaper
Availability	Not everywhere	Easily available
Size variation	Specific for each children	Can be used by child of different age group by manipulating the bar
External-rotation maintenance	By winged nut manipulation	By bar manipulation

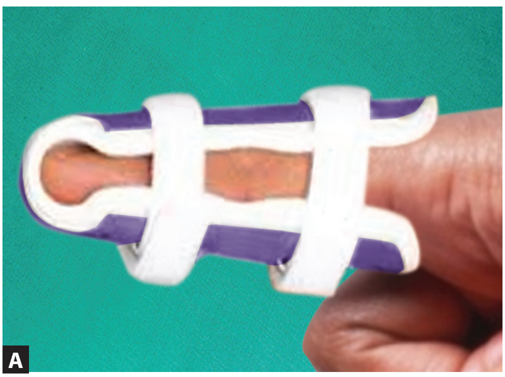
CHAPTER

38

Upper Limb Orthosis

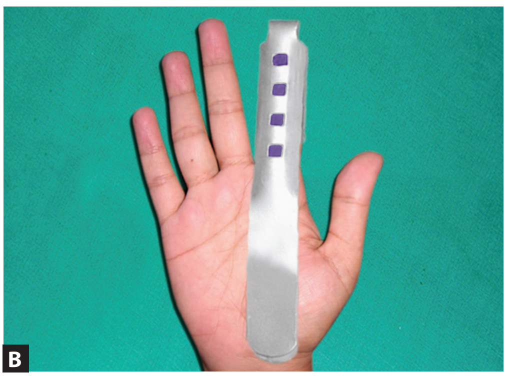
HAND ORTHOSIS (FIGS 38.1A TO E)

- It may be static or dynamic.
- *Components of orthosis:* It is made up with metal sheets, thermoplastic, fabrics, rubber, leather, etc.
- *Function:*
  - It restricts the movement of interphalangeal joint and some time metacarpophalangeal joint also.
  - It also acts as corrective splint.
  - In some cases, it allows the guarded movement of interphalangeal joints.
- *Common hand orthosis (HO) are:*
  - *Finger cot:* It immobilizes the interphalangeal joints in cases of sprain, strain and phalangeal fractures. An another splint called **frog splint** is also used for the same purpose.
  - *Long finger extension splint:* It immobilizes the metacarpophalangeal joint along with interphalangeal joints. Splint is used for finger joint injuries and phalangeal fractures.
  - *Mallet finger splint:* It acts on the principle of 3 point pressure. It immobilizes the distal interphalangeal joints of fingers or interphalangeal joints of thumb in extension position and also corrects its flexion deformity.
  - *Ring and figure 8 splint:* It also acts on the principle of three point pressure and used for correction of rheumatoid



A

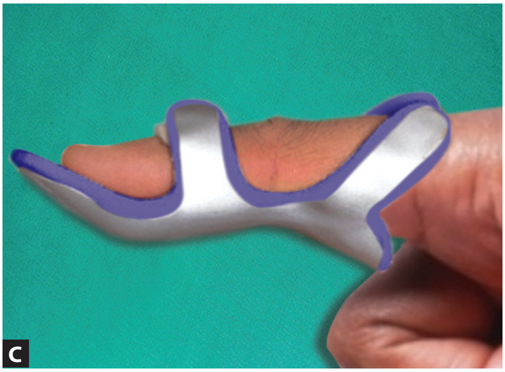
Finger cot



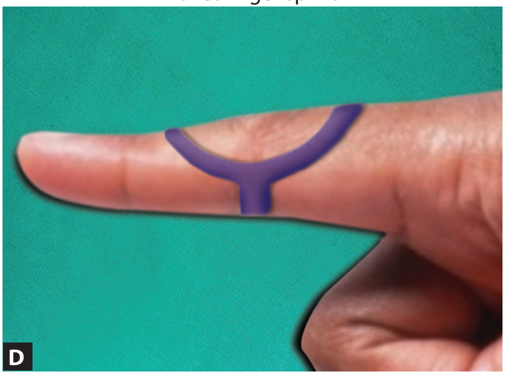
B

Long finger extension splint

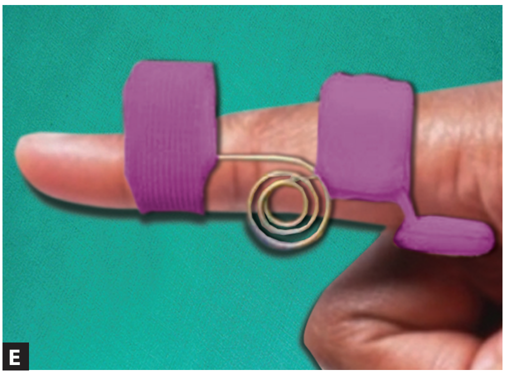
Figs 38.1A and B



Mallet finger splint



Ring and figure 8 splint



Capner's spring coil splint

Figs 38.1C to E

Figs 38.A to E Hand orthosis (HO)

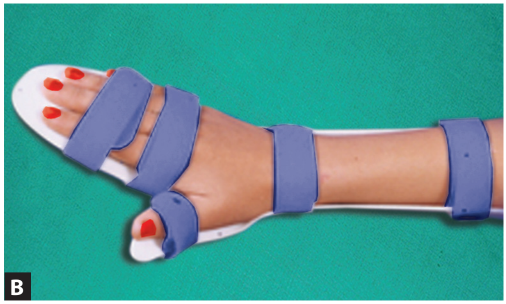
hand deformity like swan-neck or boutonniere.

- *Capner's spring coil splint:* It also acts on the principle of three point pressure system and used for mobilization of interphalangeal joints contracture.

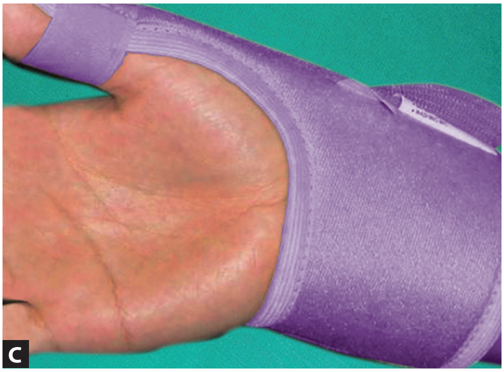
WRIST HAND ORTHOSIS (FIGS 38.2A TO E)

- It may be dynamic or static.
- *Components of orthosis:* It is made up with metal sheets, thermoplastic, fabrics, rubber, leather, etc.
  - Forearm and hand piece
  - Straps
  - Accessories like rubber coil, metallic spring coil, etc.
- *Function:*
  - It immobilizes the wrist and metacarpophalangeal joint and sometimes interphalangeal joint also.
  - It corrects deformity at wrist and metacarpophalangeal joints.
  - It provides guarded movement at wrist and metacarpophalangeal joints.
- *Common wrist hand orthosis (WHO) are:*
  - *Wrist hand stabilizer or resting splint:* This is an immobilization splint that maintain the wrist in JAMES' (functional) position. The common indication are sprain/strain around wrist and metacarpophalangeal joint, fractures radiocarpal and metacarpal bones, acute infection and inflammation, postoperative conditions, etc.
  - *Cock-up splint:* This is an immobilization splint maintains wrist in extension with help of volar support. The common indications are; sprain/strain, arthritis, tendinitis, carpal tunnel syndrome or other painful condition of wrist.
  - *Thumb spica:* This is also an immobilization splint which maintain the wrist in 10°–20° of extension and thumb in slight flexion and palmar abduction. It is used for immobilization of thumb (1st carpometacarpal, metacarpophalangeal and interphalangeal joint) along with wrist in various traumatic and nontraumatic condition.
  - *Knuckle-Bender splint:* This is a deformity correcting splint which acts on the principle of three point pressure. These pressure points are adjusted in such

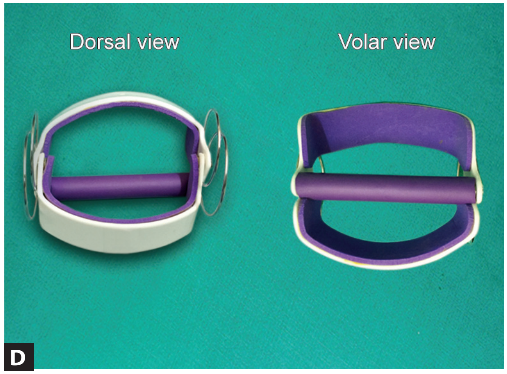
Wrist hand stabilizer



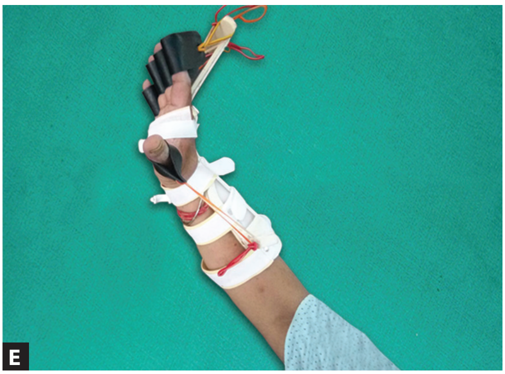
Cock-up splint



Thumb spica



Knuckle-Bender splint



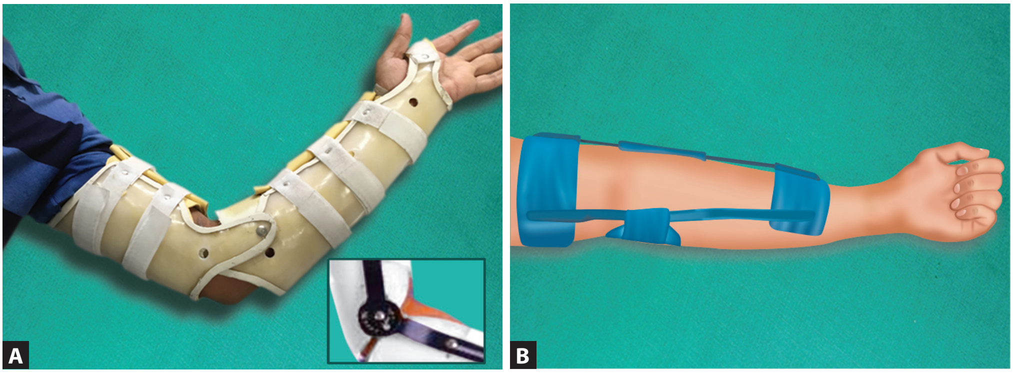
Dynamic Cock Up splint

Figs 38.2A to E Wrist hand orthosis (WHO)

manner when all fingers are loaded with flexion; the extended metacarpophalangeal joints tends to achieve position of flexion, e.g. claw hand.

– *Dynamic Cock Up splint:* This is a functional splint where wrist is maintained in almost 45° of extension and extension of finger are sabotaged by recoiling of actively flexed finger on rubber loop system, e.g. wrist drop.

- *Kleinert splints* are designed as wrist extension blocking or flexion blocking splint commonly used for flexion tendon and extension tendon repair respectively.
- *Oppenheimer splint:* This is also a functional splint that secures extension of wrist and finger when all fingers are flexed over padded spring coil system. It is meant for wrist drop but



Figs 38.3A and B Elbow orthosis (EO): (A) Elbow ROM; (B) Elbow extension orthosis

due complication like friction blister and improper stabilization of wrist in splint; these are not very common.

ELBOW ORTHOSIS (FIGS 38.3A AND B)

Elbow ROM

- This is commonly use upper limb orthosis.
- *Components of orthosis:* It is made up of metal bars, fabrics or thermoplastic material.
  - Arm and forearm piece
  - Elbow joint
  - Straps
- *Function:* It can allow the movement of elbow as per requirement or can keep the elbow in a particular position, e.g.
  - For postoperative mobilization of elbow.
  - For sprain, strain or fracture around elbow.
  - For stabilization of unstable joint.

Elbow Extension Orthosis

- It is a nonarticular orthosis made up of canvas and rigid metal strips which maintains the elbow in extension position.
- This is commonly used in spastic elbow like cerebral palsy cases.

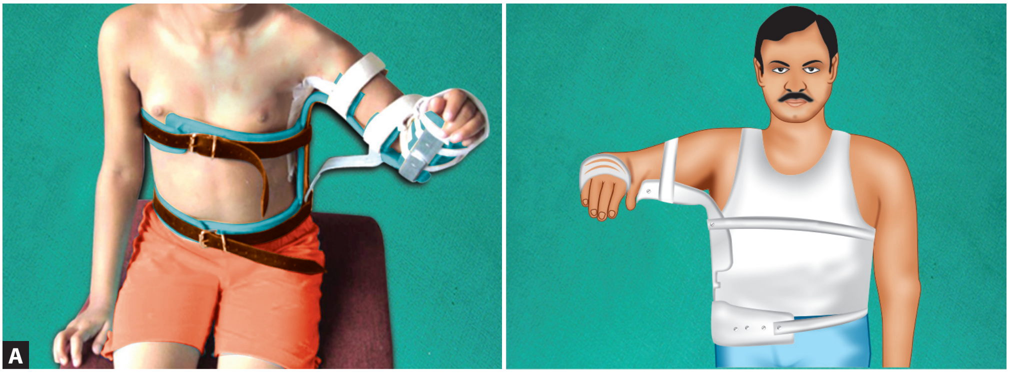
SHOULDER ORTHOSIS (FIGS 38.4A TO C)

Air-plane Splint

- It is actually shoulder abduction orthosis made up of aluminum or thermoplastic.
- *Components of orthosis:* It may be single piece or in separate unit.
  - Trunk piece
  - Arm and forearm support
  - Straps.
- *Function:* It maintain shoulder in 90°–120° of abduction position and 15°–20°of forward flexion, e.g.
  - In brachial plexus injury
  - After shoulder surgery like rotator cuff tear
  - In burn cases
  - In adduction contracture.

Figure of 8 Brace: (Clavicular Brace)

- It is available readymade or prepared with roller bandage and cotton. It is always used with a sling.
- *Parts of orthosis:*
  - Two foam filled stockinet strips—fitted around shoulder



Air-plane splint

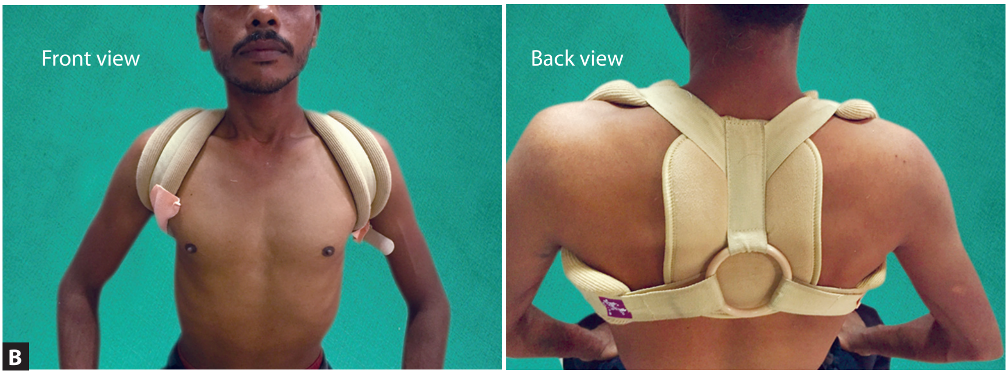


Figure of 8 brace: (Clavicular brace)

Sling and swathe immobilize (Universal shoulder immobilizer)

Figs 38.4A to C Shoulder orthosis (SO)

  - A plastic ring holding both strips—lies in inter-scapular region
  - Velcro straps.
- *Function:*
  - It restricts the movement of pectoral girdle.
  - It produces protraction of scapula and compression over axilla.
- *Indication:* For fracture clavicle.

Sling and Swathe Immobilize (Universal Shoulder Immobilizer)

- It is a combination of cuff and collar along with an arm chest bandage.
- *Parts of orthosis:* Fabric made
  - Forearm holding pouch with sling.
  - A wide arm trunk strap.
- *Function:* It restricts movement around shoulder, e.g.
  - Shoulder dislocation and proximal humeral fracture.
  - After surgey around shoulder.

SPECIAL ORTHOSIS IN UPPER LIMB (TURN BUCKLE SPLINT) (FIG. 38.5)

- It is a dynamic splint.
- *Components of orthosis:* Thermoplastics is main constituent.

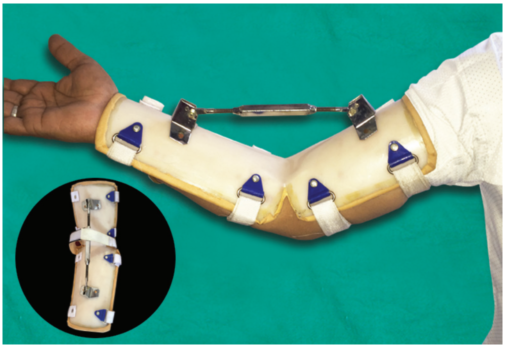


Fig. 38.5 Turn buckle splint

  - Arm, forearm or hand piece
  - Joint support (for elbow or wrist)
  - Metallic turn buckle system.
- *Function:* It produces gradual stretching over contracted joint by its turn-buckle mechanism, e.g.
  - Stiff elbow
  - Wrist deformity like Volksman ischemic contracture.
- *Advantages:*
  - Corrects contracture of soft tissue very fast.
  - Decreases rehabilitation time.
  - Minimum atrophy of limb.
  - Excellent patients' compliance.

CHAPTER

39

Spinal Orthosis

Spinal orthosis are playing a major role in management of spine ailments. Here cervical orthosis are described in order of their degree of stabilization offered by them.

CERVICAL ORTHOSIS (CO)

Soft Cervical Collar: Thomas Collar (Fig. 39.1)

- It extends superiorly from base of mandible and superior nuchal line to manubrium and C-7 spine inferiorly.
- Soft variety composed of polyethylene foam, spongy rubber and cotton covered with stockinet and fabricated for different neck sizes.
- *Components of cervical collar:*
  - Circumferential collar
  - Velcro strap
  - Anterior or posterior openings: For aeration.
- *Functions:*
  - Kinesthetic reminder to limit cervical motion—relieve inflammation.
  - Heat retention for pain relief.
  - *Motion control:*
    - *Flexion:* 26%
    - *Lateral bending:* 8%
    - *Rotation:* 17%.
- *Indications:* Commonly used for mild soft-tissue strain and sprain, spasm, spondylosis, disc diseases, etc.

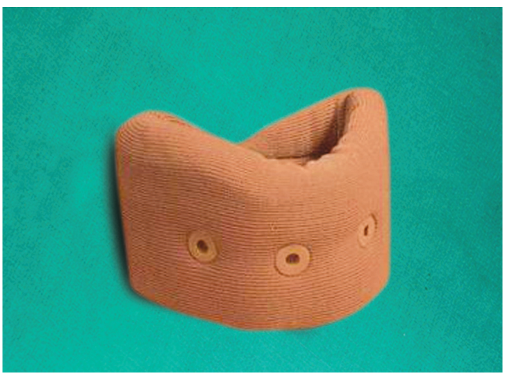


Fig. 39.1 Soft cervical collar: Thomas collar

Hard Cervical Collar (Fig. 39.2)

- Same as soft collar but rigid variety, made up of hard polyethylene (plastazote).
- *Function:* Same as soft cervical collar with some more restriction of cervical movement.
- Its indications are same as soft cervical collar but in moderately severe conditions.

Philadelphia Collar (Fig. 39.3)

- Semi-rigid or rigid variety

Fig 39.2 Hard cervical collar

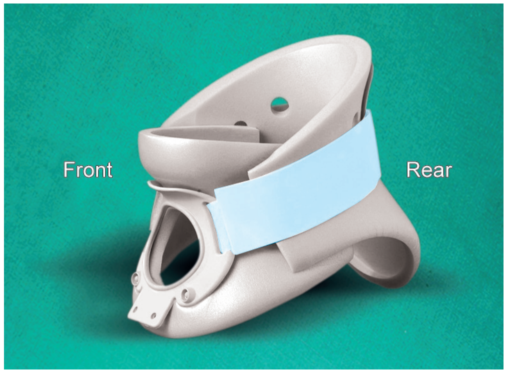


Fig. 39.3 Philadelphia collar

- *Components of Philadelphia collar:*
  - Molded polyethylene foam strengthen with plastic sheet
  - The two separate pieces are fitted around neck with help of straps.
- *Function:*
  - Kinesthetic reminder
  - *Motion control:*
    - Flexion-extension—65–70%
    - Lateral bending—30–35%
    - Rotation—60–65%.
- *Indications:* Used for temporary immobilization in cases of cervical spine injury; more effective in injury above C3 level.

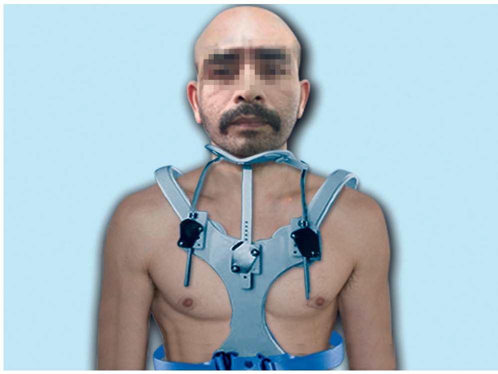


Fig. 39.4 Sterno-occipito-mandibular immobilizer (SOMI) brace

Sterno-Occipito-Mandibular Immobilizer (SOMI) Brace (Fig. 39.4)

- A rigid frame design
- *Parts of orthosis:*
  - Anterior sternal plate
  - Mandibular support
  - Occipital support
  - *Three connecting rods:*
    - One anterior post—to hold mandibular support
    - Two anterolateral post—to hold occipital support.
  - Shoulder harness
  - Trunk straps.
- *Function:* It extends more inferiorly into the thoracic region for greater control of cervical motion at all cervical spine levels but best results have been obtained up to C5 levels.
  - Flexion-extension—80%
  - Lateral bending—35%
  - Rotation—60–65%.
- *Indication:* Commonly used in stable spinal fracture-dislocation and moderate-to-severe soft tissue damage.

Four Post Collar (Poster Brace) (Fig. 39.5)

- A rigid frame design
- *Parts of orthosis:*
  - Sternal pad
  - Mandibular support
  - Occipital support

- Four connecting rods:
  - Two anterior post—to hold mandibular support
  - Two posterior post—to hold occipital support.
- Shoulder Harness
- Straps
- *Function:* Its function is same as SOMI brace but it offers some more motion control than above
- Flexion-extension—80%
- Lateral bending—55–80%
- Rotation—70%.

- *Indication:* Commonly used in stable spinal fractures and moderate-to-severe soft tissue damage.

Fig. 39.5 Four post collar (Poster brace)

Cervical Halo (Fig. 39.6)

- A rigid frame invasive bracing system where screws are directly inserted into the skull.
- *Parts of orthosis:*
  - Oval ring with 4 pins (halo)—metallic or carbon fibers.
  - Padded thermoplastic vest.
  - Four metallic bars (two anterior two posterior)—attaching cranial ring and vest.
- *Function:* It provides maximum motion control at all cervical levels.
  - Flexion-extension—90–96%
  - Lateral bending—92–96%
  - Rotation—98–99%.
- *Use:* Commonly used in unstable fracture-dislocation of spine.
- Comparision of cervical control among different cervical orthosis.

EXTENDED CERVICAL ORTHOSIS

Cervicothoracic Orthosis (CTO): Minerva Jacket (Fig. 39.7)

- A rigid frame, custom made total contact orthosis.
  - Entire skull is covered with brace except face area and extending to inferior costal margin below.

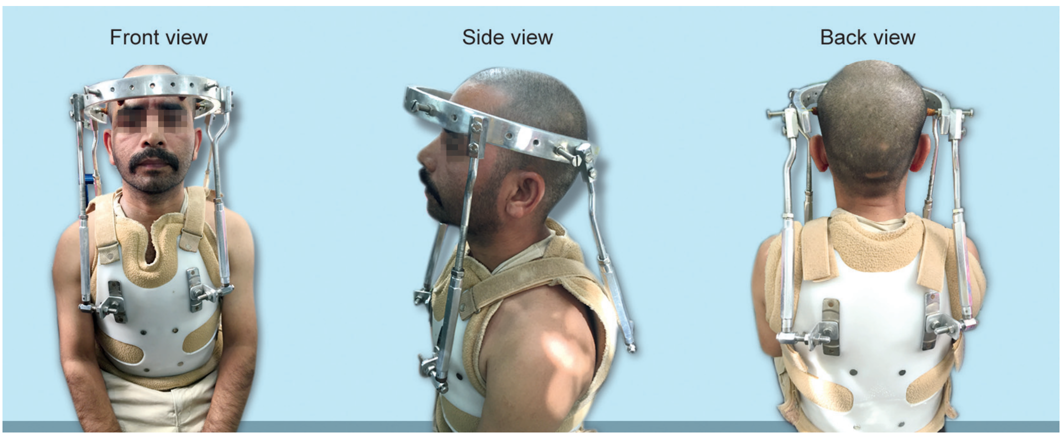


Fig. 39.6 Cervical halo
Courtesy: Dr Shailendra Khare

Comparison of cervical control among different cervical orthosis						
	Soft cervical collar	*Hard cervical collar*	*Philadelphia collar*	*SOMI*	*Four post collar*	*Cervical halo*
Flexion-extension	26%	Slightly greater than soft cervical collar	65–70%	80%	80%	90–96%
Lateral bending	8%	Slightly greater than soft cervical collar	30–35%	35%	55–80%	92–96%
Rotation	17%	Slightly greater than soft cervical collar	60–65%	60–65%	70%	98–99%

Fig. 39.7 Cervicothoracic orthosis (CTO): Minerva Jacket

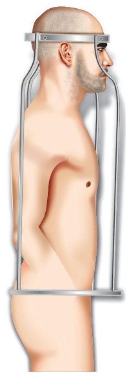


Fig. 39.8 Cervicothoracolumbosacral orthosis (CTLSO)—Halo pelvic brace

- Initially fabricated with POP cast but now thermoplastics are the main raw material.

- *Function:* It provides maximum motion control at lower cervical levels and cervico-thoracic junction.
- Commonly indicated in traumatic and Pott's spine cases.

Cervicothoracolumbosacral Orthosis (CTLSO): Halo Pelvic Brace (Fig. 39.8)

- A rigid frame invasive bracing system having historical importance only.
- *Parts of orthosis:*
  - Cervical halo
  - Four spring loaded distraction bars (two anterior and two posterior)
  - Two threaded rod (inserted through iliac tubercle and out from posterior superior iliac spine of pelvic bone)
  - Two pelvic hoop (attached with threaded rod with universal clamp).
- *Functions:*
  - Limits all spinal motion.
  - Correction of deformity by differential distraction.
- *Indications:*
  - Used for spinal immobilization in fracture or Pott's spine cases.
  - Correct or reduce deformities of spine as in scoliosis or TB.

Fig. 39.9 Taylor's brace

Fig. 39.10A Anterior hyperextension orthosis (ASH): Jewett type

THORACOLUMBOSACRAL ORTHOSIS (TLSO)

Taylor's Brace (Fig. 39.9)

- Semi-rigid design
- *Parts of othosis:*
  - Abdominal—corset with thoracic extension
  - Paraspinal bars
  - Shoulder harness
  - Straps.
- *Functions:*
  - It acts on the principle of three point pressure and limits flexion and extension movement of thoracolumbar spine.
  - It also increases intra-abdominal pressure and convert abdominal cavity into semi-rigid cylinder that helps spinal motion restriction.
- *Indication:* Commonly used for spinal pathology of level T4-L2
  - Spinal osteoporosis
  - Spinal trauma
  - Degenerative disc disease
  - Pott's spine.

Anterior Spinal Hyperextension (ASH) Orthosis (Figs 39.10A to C)

- Semi-rigid frame orthosis, commonly used design are **Jewett** type and **cruciform** type.

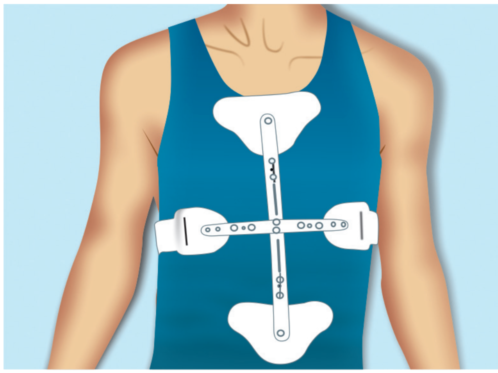


Fig. 39.10B Anterior hyperextension orthosis (ASH): Cruciform type

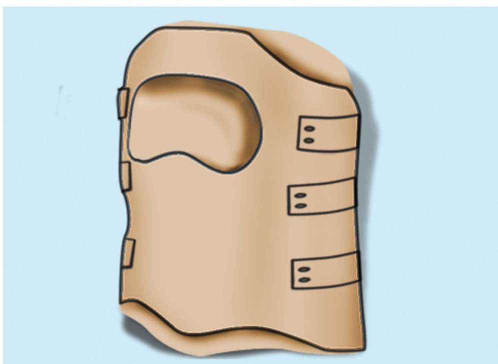


Fig. 39.10C Molded TLSO orthosis: Body jacket orthosis

- *Parts of orthosis:*
  Jewett type
  - Anterolateral rectangular frame
  - *Pads:* 1-sternal, 1-suprapubic and 3 thoracolumbar, i.e. two lateral and one posterior
  - Straps.

  Cruciform type (most common)
  - An anterior cross-frame
  - *Pads:*
    - Sternal and suprapubic pads attached with vertical bar of frame.
    - Two lateral thoracolumbar pads attached with horizontal bar.
    - One posterior thoracolumbar paddings.
  - Straps.
- *Function:* It also acts on the principle of 3 point pressure and limits the flexion of thoracolumbar spine and provide hyperextension.
- *Indications:* Commonly used for spinal pathology of level T4-L2.
  - Prolapsed intervertebral disc.
  - Moderate soft tissue strains and sprains.
  - Pre- and postoperative immobilization of fracture spine.

Molded TLSO Orthosis: Body Jacket Orthosis

- A rigid frame, custom-made total contact orthosis.
  - Its superior margin start just below the sternal notch and inferiorly extends up to suprapubic area so and so patient can easily sit on chair.
  - It is prepared by taking negative cast with POP and finally positive with thermoplastics.
- *Functions:*
  - It also acts on the principle of 3 point pressure and limits the flexion-extension of thoracolumbar spine.
  - It also increases intra-abdominal pressure and contribute in spinal motion restriction.
- *Indications:* Commonly used for spinal pathology of level T4-L2.
  - Prolapsed intervertebral disc
  - Moderate soft tissue strains and sprains
  - Pre- and postoperative immobilization of fracture spine.

LUMBOSACRAL ORTHOSIS

Lumbosacral Corset (Fig. 39.11A)

- Corset is a fabric garment that encircle the part of body.
- LS corset encompasses the abdomen and pelvis and support the lumbosacral spine.
- *Functions:*
  - Kinesthetic reminder and restrict only terminal movement.
  - It also increases intra-abdominal pressure and make spine rigid to someextent.
- Commonly used for spinal pathology level LI-L4 of lesser severity.
  - Spinal strain and sprain
  - Degenerative lumbar spine disc disease
  - Sciatica.

LS Brace: Chair Back Orthosis/ Knight 's Orthosis (Fig. 39.11B)

- Semi-rigid design orthosis
- Components of LS brace:
  - Pelvic and thoracic band

Fig. 39.11A Lumbosacral corset

Fig. 39.11B LS brace: Chair Back Orthosis/Knight's orthosis

- Two posterior metallic upright
- Two lateral metallic upright
- Leather/canvas band
- Straps.

- *Functions:*
  - Acts on the principle of 3 point pressure and restrict spinal motion more than the corset.
  - Increases intra-abdominal pressure and contribute in segmental spinal rigidity.
- *Indications:* Commonly used for spinal pathology level L1-L4.
  - Spinal osteoporosis
  - Spinal trauma
  - Degenerative disc disease
  - Spondylosis
  - Lumbosacral strain
  - Sciatica.

☑ *Note:* Thoracolumbar orthosis (corset and brace) are also being prepared on the basis of same principle mentioned above.

SPECIAL ORTHOSIS FOR SCOLIOSIS: MILWAUKEE AND BOSTON BRACE

- *Principle:* Three point (for single curve) or four point (for double curve) pressure system.
- *Indication:* Idiopathic scoliosis with curve between 20°–50°.
- *Contraindications:*
  - Congenital scoliosis—surgical
  - Idiopathic scoliosis with:
    - Curve <20°—observation
    - Curve >50°—surgical
    - Any curve in skeletally mature patient—surgical.
- *Advantages:*
  - Minimal restriction of child activity
  - Minimal restriction of respiration
  - Skin aeration possible (open design)
  - Length adjustment possible (CTLSO).
- *Disadvantages:*
  - Ugly external appearance.
  - Re-fabrication as age advances
  - Heating effect and skin problems (closed design)
  - Growth disturbance of mandible and teeth (CTLSO).
- *Wearing schedule of brace:*
  - Wearing period should be increased slowly.
  - First start wearing in day then go for night.
  - Wear 23 hours daily till skeletal maturity.
  - 1 hour of unworn period is used for bathing, etc.
  - Radiological evaluation for curve correction is needed at interval of 2–3 month.
  - If rate of curve progression is less than 5°, then 5–6 hours of brace weaning is allowed (Few recommendation).
  - Wear the brace for 1–2 year, especially in night even after skeletal maturity (Few recommendation).

Milwaukee Brace (Fig. 39.12A)

- A rigid frame design, first developed in Milwaukee (USA) for treatment of post-polio residual deformity case.
- *Parts of orthosis:*
  - Neck ring
  - Chin piece
  - Occipital support
  - *Adjustable bars:* One anterior and two posterior

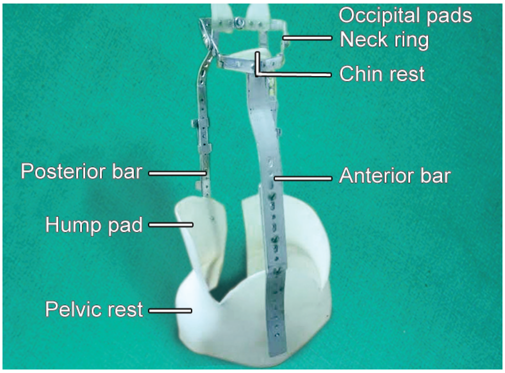


Fig. 39.12A Milwaukee brace

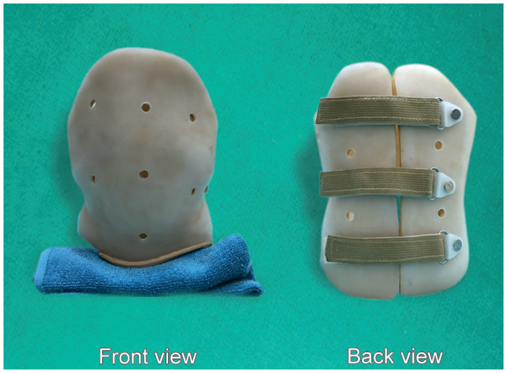


Fig. 39.12B Boston brace

- Hump pad
- Pelvic rest.
- *Functions:*
  - Longitudinal distraction of whole spine.
  - A transverse loading on spine by 3 pressure points from convex side to concave side.
- *Indication:* Traditional method of scoliosis treatment for curve apex at or above T8.

Boston Brace (Fig. 39.12B)

- A rigid frame design, first developed in Boston (USA).
  - It extends from thoracic region to sacral region.
  - It is prepared by taking negative cast with plaster of Paris and positive is made by thermoplastic material.
- *Function:* It allows transverse loading on spine by 3 pressure point from convex side to concave side.
- *Indication:* Traditional method of scoliosis treatment for thoracolumbar scoliosis whose apex is below T8 vertebral level.

CHAPTER

40

Basics about Prosthesis

The history of prosthesis is as old as amputation of limb. A long journey have been covered for development of prosthesis ranging from ugly and cumbersome wooden limbs to highly efficient and cosmetic prosthesis.

PROSTHESIS DEFINITION

Replacement of missing part of the body is called prosthesis.

FUNCTIONS OF PROSTHESIS

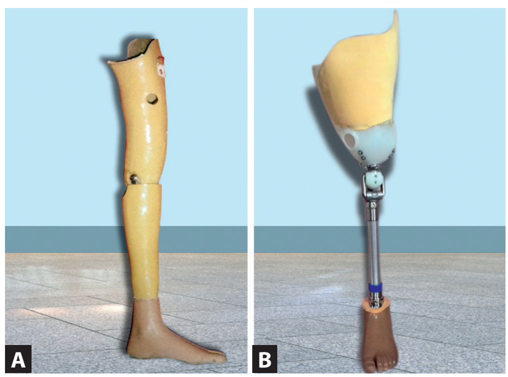
- It provide missing part of body
- It provide variable range of physical activity
- It provide variable range of professional activities
- It provide mental satisfaction to the individual.
- It increases the social acceptance of patient.

CLASSIFICATION OF PROSTHESIS (ANATOMICAL BASIS)

- *Lower limb prosthesis:*
  - Above knee (AK) prosthesis
  - Below knee (BK) prosthesis
- *Upper limb prosthesis:*
  - Above elbow (AE) prosthesis
  - Below elbow (BE) prosthesis

CLASSIFICATION OF PROSTHESIS (ON THE BASIS OF FABRICATION) (FIGS 40.1A AND B)

- *Exoskeleton prosthesis (ESP):*
  - Durable but not adjustable
  - *Parts of ESP:*
    - Socket
    - Shank
    - Foot and ankle assembly
- *Endoskeleton prosthesis (ESP):*
  - *Cosmetic and adjustable:*
  - *Parts of ESP:*
    - Socket



Figs 40.1A and B (A) Exoskeleton; (B) Endoskeleton prosthesis
[*Courtesy:* Sant Prakash Gautam MPO (NIOH), Kolkata]

- Socket adapter
- Pylon
- Ankle adapter
- Foot.

CLASSIFICATION OF PROSTHESIS (ON THE BASIS OF TIME OF WEARING)

- *Immediate postoperative prosthesis:* Just after sugery.
- *Definitive prosthesis:* After 3–6 months of surgery, after skin maturation.

IMMEDIATE POSTOPERATIVE PROSTHESIS (FIG. 40.2)

- Immediate postoperative prosthesis (IPOP) is prosthesis fitted over a specialized dressing covered by plaster cast with aim to ambulate the patient as soon as possible.
- *Parts:*
  - Socket
  - Pylon
  - Prosthetic foot
- *Function of IPOP:*
  - It controls edema of limb.
  - It promotes healing of wound.
  - It prevents contracture of joint.
  - It promotes ambulation of patient.
  - It provides psychological satisfaction.
- *Perfect candidate:* Young individuals
- *Complication:*
  - Cast loosening
  - Heaviness of cast
  - Noncosmetic
  - Repeated removal for dressing.

Fig. 40.2 Immediate postoperative prosthesis (IPOP)

MATERIAL FOR PROSTHESIS FABRICATION

- Plaster of Paris
- Wood (whilock)
- Plastic and rubber
- Metal and alloy
- Various type of fabrics.

CRITERIA OF A GOOD PROSTHESIS

- One who fulfill its function.
- Light weight
- Compliance to the patient.
- Proper fitting to limb.
- Cosmetically acceptable.

COMPLICATIONS OF PROSTHESIS

- Atrophy of the part.
- Skin complication.

CHAPTER

41

Lower Limb Prosthesis

COMPONENTS OF LOWER LIMB PROSTHESIS

- Prosthetic foot
- Prosthetic shank
- Prosthetic socket and suspension below-knee prosthesis (BKP)
- Prosthetic knee joint above-knee prothesis (AKP)
- Prosthetic socket and suspension (AKP).

PROSTHETIC FOOT (FIGS 41.1A TO D)

- *Classification of prosthetic foot:*
  - *Nonarticular:*
    - Nonenergy storing.
    - Energy storing.
  - *Articular:*
    - Single axis
    - Multiple axis.
- *Nonenergy storing foot:*
  - Most commonly used
  - Light, durable and economic
  - Best for juvenile and geriatric persons
  - For Jaipur foot, solid ankle cushioned heel (SACH) foot, etc.
- *Energy storing:* Indicated for more active amputee.
- *Single axis foot:*
  - Heavier and less durable
  - Commonly used in transfemoral amputees.
- *Multiaxis foot:*
  - Compatible for walking on uneven ground
  - Good for excessively scarred and sensitive stump (better shock absorber)
  - Heavier, less durable and more costly.

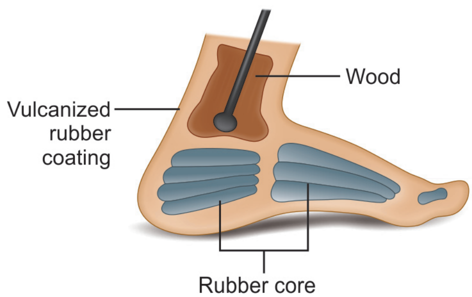
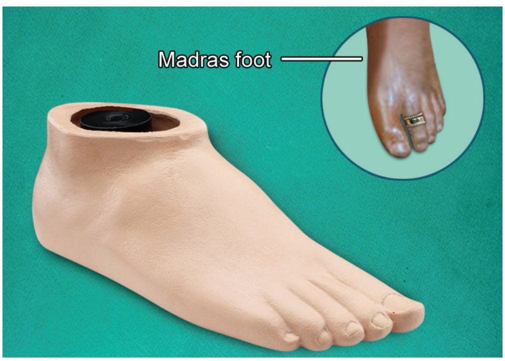


Fig. 41.1A Jaipur foot

Comparison between Jaipur/SACH foot

	Jaipur foot	*SACH foot*
Name	Made in Jaipur by Dr PK Shetty	Solid ankle cushion heel
Parts	Rubber core + wooden block + vulcanized rubber coating	Wooden keel+ rubber body + straps of hard and soft rubber in heel
Raw material availability	Easily available	Not easily available
Look	Like normal foot	Have to wear under shoes
Durability and water resistance	More	Lesser
Squatting and cross leg sitting	Possible	Possible
Ankle and foot movement like dorsi/plantar flexion +inversion/ eversion+ rotation	All three possible	Limited but heel push off present
Walking on uneven surface and bare foot walking	Possible	Not possible
Fatigue resistance	More	Easily cracks
Maintenance	Minimum	More
Cost-effectiveness	More	Less in Indian scenario
Availability	Everywhere	Not everywhere

- *Madras foot:*
  - It is also a modification of SACH foot.
  - Crafted in Government Institute of Rehabilitation Medicine (GRIM), Chennai previously called Madras.
  - There is alternate layers of soft and hard rubber separated by 5 mm thick canvas rubber sheet.
  - Normal looking dorsum, toes and tendo-Achilles.
  - Advantage of bare foot walking, durability and cultural value like toe ring wearing, etc.
- *Solid ankle-flexible-endoskeletal (SAFE) foot:*
  - It stands for solid ankle and flexible endoskeleton.
  - It is a modified SACH foot.
  - It has a rigid ankle block.
  - It has flexible keel to accommodate uneven surfaces and promote some movements like inversion and eversion.
  - Its cushioned heel acts as shock absorber and also permit plantar flexion.



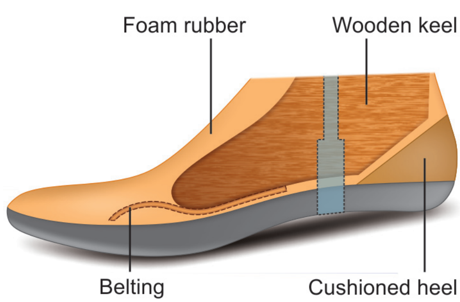


Fig. 41.1B SACH (Solid ankle cushion heel) foot

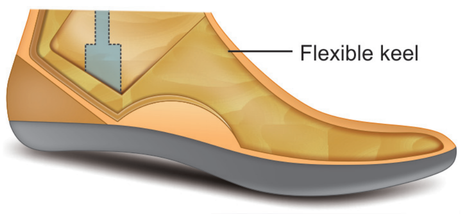


Fig. 41.1C SAFE foot

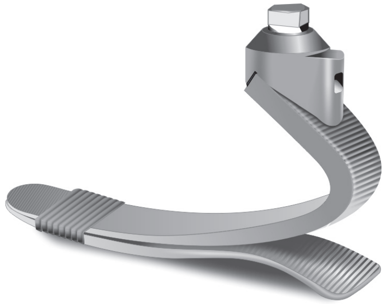
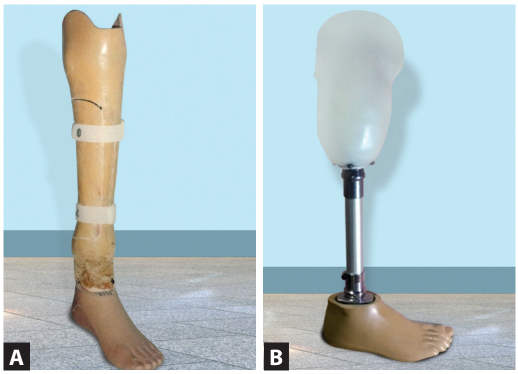


Fig. 41.1D Energy storing foot

PROSTHETIC SHANK (FIGS 41.2A AND B)

- *Exoskeletal:* It is durable but has little scope for alignment changes after finishing.
- *Endoskeletal:* Lighter, cosmetic and easily adjustable.



Figs 41.2A and B Prosthetic shank. (A) Exoskeletal; (B) Endoskeletal
[*Courtesy:* Sant Prakash Gautam MPO (NIOH), Kolkata]

PROSTHETIC SOCKET AND SUSPENSION (BKP) (FIG. 41.3)

- *Socket:*
  - Patellar tendon bearing (PTB) type—most commonly used
  - *Bent knee type:*
    - Used in severe knee contracture
    - Receives all pressures from ischium, glutei and thigh and bypasses the tibia.
- *Suspension:*
  - With suction action
  - Without suction action—supracondylar cuff, a leather made strap.
- Soft inserts are applied in socket to absorb the pressure effect of socket, its absolute indications are:
  - Peripheral vascular disease
  - Excessive scarring of stump
  - Stump with minimal subcutaneous tissue.

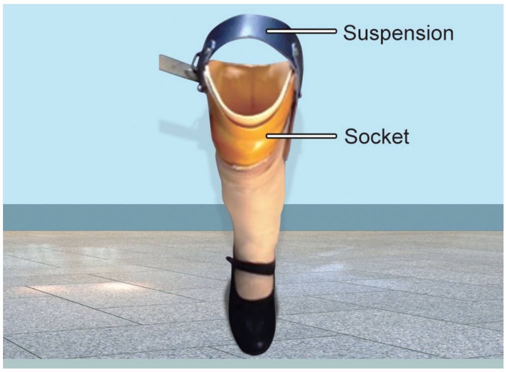


Fig. 41.3 Prosthetic socket and suspension (BKP)
[*Courtesy:* Sant Prakash Gautam MPO (NIOH), Kolkata]

PROSTHETIC KNEE JOINT (AKP) (FIG. 41.4)

Prosthetic knee joint is considered on the following basis:

- *Axes:* Single axis and polycentric
- *Stability:* Manual locking type and weight-activated stance control

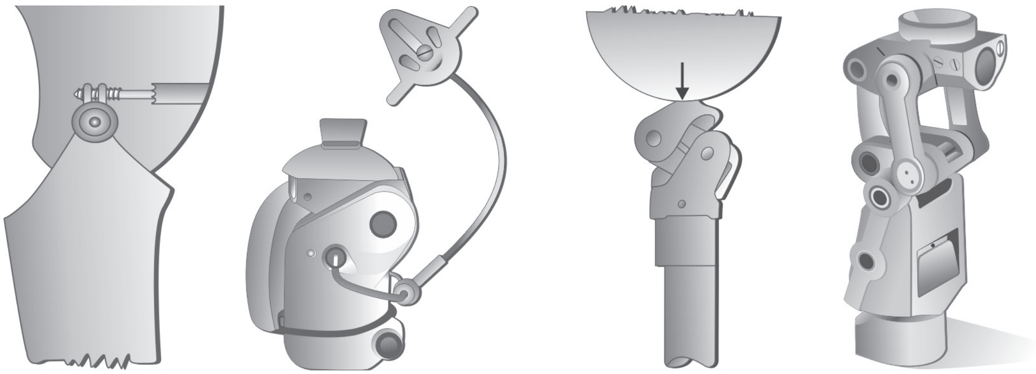
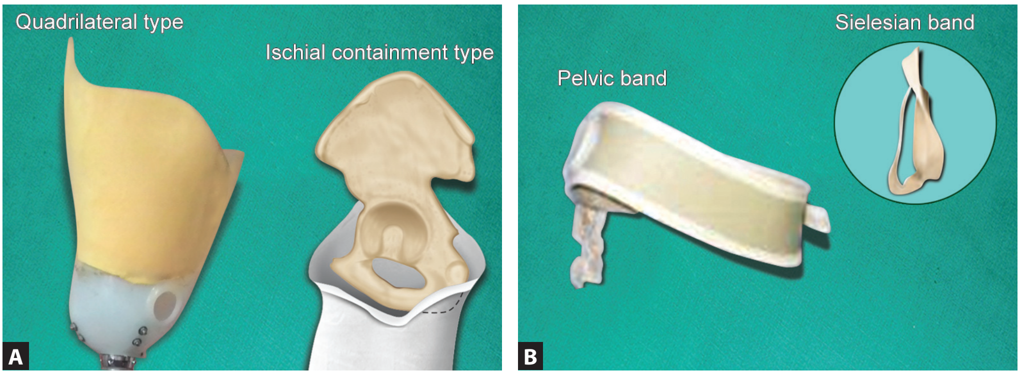


Fig. 41.4 Prosthetic knee joint (AKP)



Figs 41.5A and B (A) Prosthetic socket; (B) Suspension (AKP)

- *Motion control:*
  - Constant friction type and variable friction type
  - Pneumatic type or hydraulic type
- Sensor controlled-microprocessor knee

PROSTHETIC SOCKET AND SUSPENSION (AKP) (FIGS 41.5A AND B)

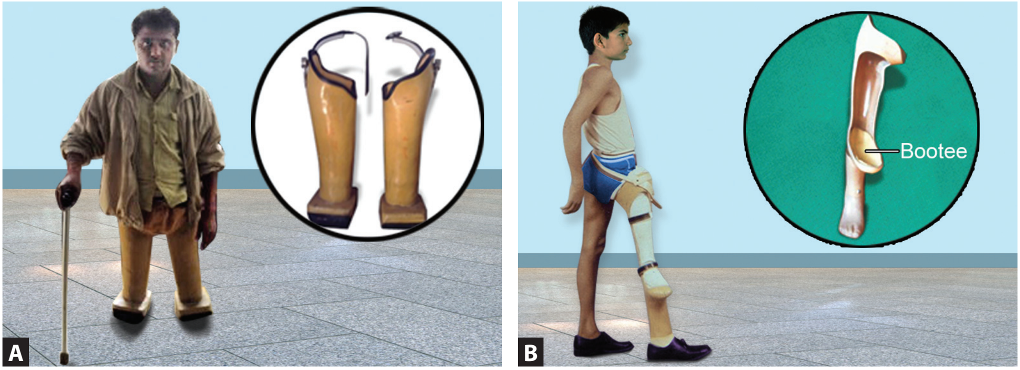
- *Socket type:*
  - Quadrilateral type
  - *Ischial containment type:* Here more energy efficient ambulation possible; perfect candidates are:
    - For active amputee
    - Patient with short residual limb
    - Patient with weak glutei muscle.
- *Suspension type:*
  - With suction action—a one way air valve is fitted at far end of socket that produces a negative suction pressure during weight bearing.
  - *Without suction action:*
    - Pelvic band
    - Silesian band—a leather made strap.

STUBBIES AND LEG EXTENSION PROSTHESIS (FIGS 41.6A AND B)

Stubbies

Features of prosthesis:

- Stubbies have only sockets no knee joints.
- Its rocker bottom feet prevents from falling backward.



Figs 41.6A and B (A) Stubbies; (B) Leg extension prosthesis
[*Courtesy:* Sant Prakash Gautam (NIOH), Kolkata]

- As center gravity of body lies nearer to ground; it provides stability hence balance can be made easily.
- Less energy expenditure during walking.

Indications and perfect candidate for stubbies:
- Bilateral transfemoral amputee.
- Shorter residual limb.
- Active individual.

Leg Extension Prosthesis

Features of prosthesis:
- The main prosthesis is meant for weight bearing.
- There is a boote projected from the main prosthesis.
  - The level of boote depends upon the shortening of limb.
  - It just supports the limb and transfer the weight to main prosthesis inefficiently.
  - It gives a ugly look to the prosthesis.

Indications:
- Congenital anomalies like proximal femoral deficiency, congenital pseudoarthrosis of tibia, fibular or tibial hemimelia.
- Incurable nonunion of lower limb.
- Lower limb deformities due to neuroparalytic disorder.

CHAPTER

42

Upper Limb Prosthesis

COMPONENT OF UPPER LIMB PROSTHESIS

- Power system
- Terminal devices
- Wrist and elbow section
- Arm and forearm system
- Socket and suspension.

POWER SYSTEM (FIG. 42.1)

- *Body powered:* It utilizes body movement to control the action of prosthetic component.
- *Electrically powered:* This is commonly called myoelectric prosthesis; it uses the action potential of muscle in action for prosthetic function.
- *Hybrid:* This is combination of body powered and electrically powered prosthesis.

TERMINAL DEVICES (FIG. 42.2)

- It is replacement of normal hand.
- *Two types:*
  - Cosmetic nonfunctional.
  - Active functional—in form of hand and hook that perform voluntary opening and closing.

WRIST UNIT (FIG. 42.3)

- It provides attachment to terminal devices with forearm section.

Fig. 42.1 Body powered upper limb prosthesis (*Courtesy:* Surjit Kumar, Patna)

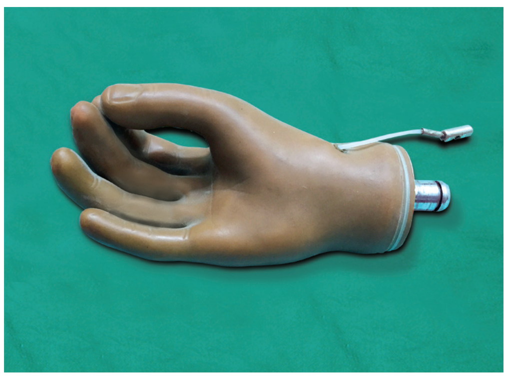


Fig. 42.2 Terminal device (hand) (*Courtesy:* Surjit Kumar, Patna)

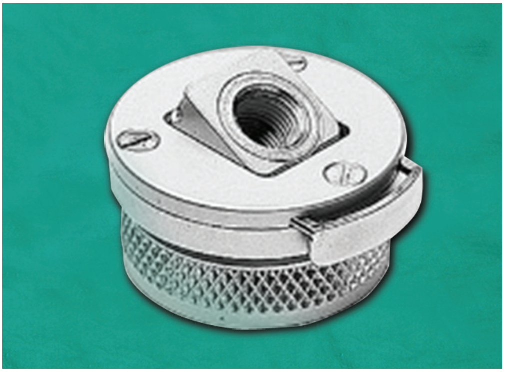


Fig. 42.3 Wrist unit
(*Courtesy:* Surjit Kumar, Patna)

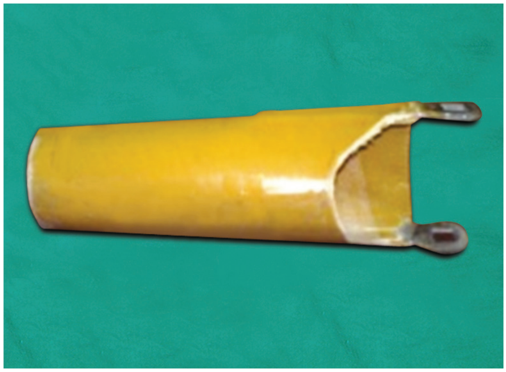


Fig. 42.4 Forearm section
(*Courtesy:* Surjit Kumar, Patna)

- *Three types:*
  - *Friction wrist unit:* Here the terminal device is kept in specific position by rotating it with normal hand.
  - *Quick change wrist unit:* Here terminal devices can be changed quickly as per requirement.
  - *Locking wrist unit:* Here hand can be locked in any position of supination and pronation.

FOREARM SECTION (FIG. 42.4)

- *Found in two form:*
  - *Forearm shell:* For above elbow prosthesis
  - *Socket:* For below elbow prosthesis.

PROSTHETIC SOCKET (BEP) (FIG. 42.5)

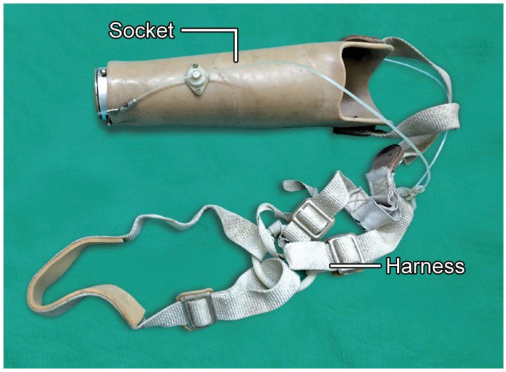


Fig. 42.5 Prosthetic socket (BEP) with harness suspended
(*Courtesy:* Surjit Kumar, Patna)

- *Harness suspended socket:* Here socket is suspended by figure of 8 harness or cross chest strap harness from shoulder.
- *Self-suspended socket:* Here suspension is provided by some bony parts of residual limb (radial or ulnar styloid process, olecranon process) or atmospheric pressure and skin traction (sleeve type).
- Soft inserts are applied in socket to absorb the pressure effect of socket, its absolute indications are:
  - Peripheral vascular disease
  - Excessive scarring of stump
  - Stump with minimal subcutaneous tissue.

ELBOW JOINT UNIT (FIG. 42.6)

- These are available for both below elbow (BE) or above elbow (AE) prosthesis.
- *BE prosthetic elbow joint:*
  - It attaches socket of prosthesis with cuff fitted on upper arm.
  - It provides stability and suspension ability.
  - It may be rigid or flexible type used as per level of amputation and range of motion of elbow.

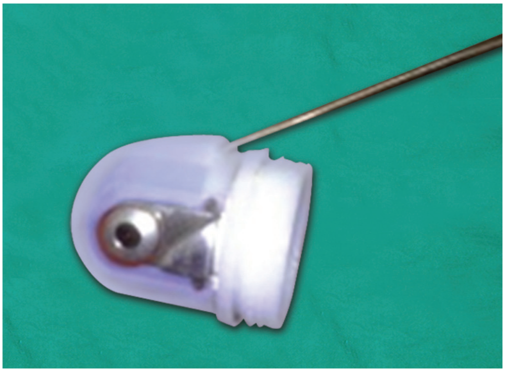


Fig. 42.6 Elbow joint unit
(*Courtesy:* Surjit Kumar, Patna)

Fig. 42.7A Prosthetic socket (AEP)
(*Courtesy:* Surjit Kumar, Patna)

- *AE prosthetic elbow joint:*
  - It consists of elbow hinge and cable system.
  - It can be fixed in various degree of elbow flexion.

PROSTHETIC SOCKET (AEP) (FIGS 42.7A AND B)

- The lateral wall of socket extends up to the acromion process of scapula to prevent the unwanted rotation of socket.
- The harness suspended socket is the most common one.

Fig. 42.7B Prosthetic socket (AEP) with harness suspended
(*Courtesy:* Surjit Kumar, Patna)

MYOELECTRIC PROSTHESIS (FIG. 42.8)

- *Principle:* The signals or action-potential of functioning muscle are picked by electrodes (sensors) on surface of skin, which activate a battery driven motor that operates the prosthetic components.
- *Components:*
  - Socket
  - Sensor electrodes
  - Electrical motor
  - Battery (power source)
  - Terminal device.
- *Advantages:*
  - Uses own muscle stimuli.

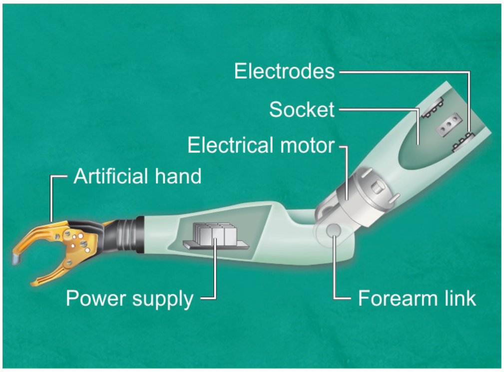


Fig. 42.8 Myoelectric prosthesis

- Less energy expenditure.
- More accurate control.
- Eliminates shoulder harness.
- Lesser body movement to control prosthesis.

- *Disadvantages:*
  - Expensive, heavy, noisy and slow.
  - Required regular servicing by expert technician.
  - Lack of proprioceptive feedback.
  - Cannot control fast and fine rhythmic movement.
  - The power source battery have to charge regularly.

CHAPTER

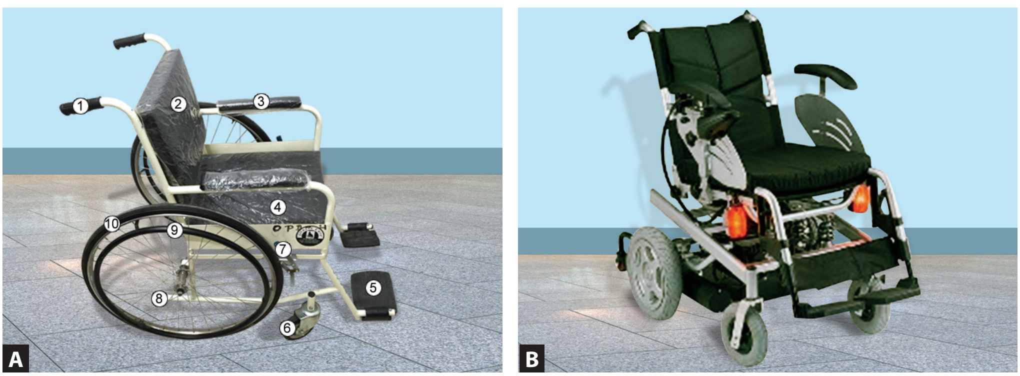
43

Mobility Aids for Patients

Locomotion is an essence of life. There are some gadgets that are utilized by patients for locomotion; these are commonly called walking aids. Patients may use these devices as a part of rehabilitation or permanently in case of any impairment.

WHEELCHAIR (SECOND HOME FOR PARAPLEGICS) (FIGS 43.1A AND B)

- *Types:*
  - Rigid frame—for sports and ragged activity.
  - Folding frame—easy for storage and portable.
- *Parts of wheelchair:*
  1. Handgrip
  2. Back rest
  3. Arm rest
  4. Seat
  5. Foot rest
  6. Castor
  7. Break
  8. Axle—antitip bar
  9. Hand rim
  10. Rear wheel.
- *Wheelchair training:*
  - About wheelchair design and structure
  - About fine tunning, e.g. hand rim holding
  - About skills like pushing, turning, etc.



Figs 43.1A and B Wheelchair: (A) Manual; (B) Motorized

- About transfer, e.g. chair to bed or vice-versa
- *Candidate of wheelchair:*
  - Hemiplegics
  - Paraplegics
  - Quadriplegics
  - Transfermoral amputee
  - Polio patient with postpolio residual deformity.

STANDARD WALKING FRAME (WALKER) (FIG. 43.2)

- This is light weight, stable and adjustable walking frame. It has four point contact on ground hence elderly and debilitated people can use it with a feeling of security.
- *Parts of frame:*
  - Four vertical metallic tubular post-attached with horizontal tubes.
  - Posterior entrance.
  - Height adjusting system.
  - Rubber tips.
- *Not a candidate:* Inadequate power in upper limb.
- *Height of hand grip:* Maintain 30° of flexion at elbow while holding the hand grips of frame. Adjust the grip at higher level in unsteady gait.
- *Use:* Used for three modes—nonweight bearing, partial weight bearing and full weight bearing
- *How to use:* Steps are as:
  - Lift the walker and move it forward
  - Go inside the frame
  - Repeat the cycle
- *Pulpit:* Standard walking frame with its grip at level of chest.
- *Reciprocal walking frame:* Each side of frame can be moved forward alternatively.

☑ *Note:* A patient of cerebral palsy having lower limb extensor weakness may keep his walker behind during walking.

ROLLATOR WALKING FRAME (WALKER ON WHEELS) (FIG. 43.3)

- This is also a adjustable standard walking frame.
- *Parts:*
  - Two rubber wheel in front.
  - Two smaller back legs with rubber tips.
  - Rear legs are in line of hand grips.
- *Not a candidate:* Elderly patient as it may roll forward and may loose balance.
- *Height of hand grip:* Same as standard walking frame.
- *How to use:* Steps are as
  - Lift the hind legs and run the rollator forward
  - Keep the hind leg on ground and go the frame
  - Repeat the cycle.

Fig. 43.2 Standard walking frame (walker)

Fig. 43.3 Rollator walking frame (walker on wheels)

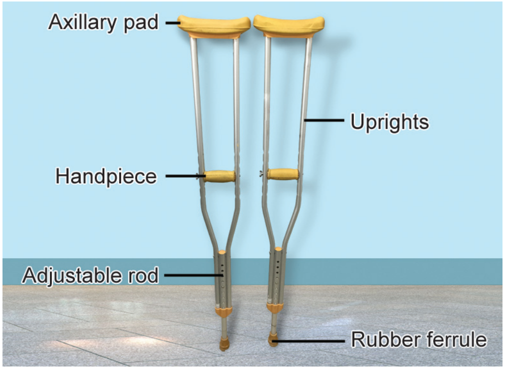


Fig. 43.4 Axillary crutches

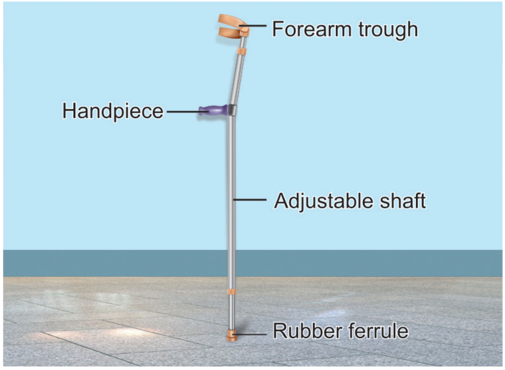


Fig. 43.5 Elbow crutches (lofstrand crutch)

AXILLARY CRUTCHES (FIG. 43.4)

- *Two types:*
  1. Wooden
  2. Metallic
- *Parts:*
  - Axillary pad
  - Handpiece (adjustable)
  - Two uprights
  - Adjustable rod
  - Rubber ferrule—prevent slippage
  - Half loop strap between two upright or a metallic gutter—prevent buckling of arm in cases of triceps weakness.
- *Length measurement of crutch:*
  - Height of patient – 41 cm (Beckwith 1965)
  - *Patient in supine position*: Anterior axillary fold to bottom of heel of shoe.
  - *Patient in standing position:* From anterior axillary fold to 15 cm lateral to 5th toe
- *How to hold the crutch:*
  - Handpiece is adjusted in such a way that elbow is in 30° flexion.
  - Adjust axillary pad 5 cm or 3 finger breath below anterior axillary fold and place the crutch tip 15 cm lateral and front to the toe.

ELBOW CRUTCHES (LOFSTRAND CRUTCH) (FIG. 43.5)

- This is less stable but more simpler crutch.
- *Parts:*
  - Angled tubular and adjustable shaft.

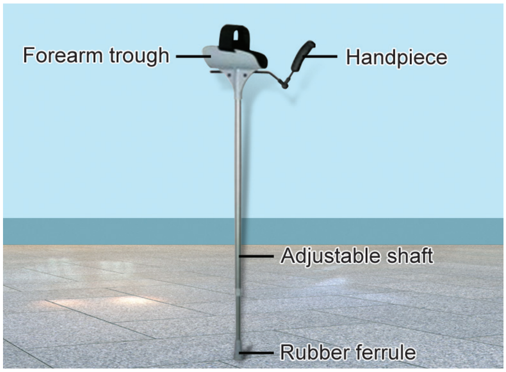


Fig. 43.6 Gutter crutch

  - Metallic or plastic made well-padded forearm cuff.
  - Handpiece
  - Rubber ferrule
- *How to hold the crutch:*
  - Height of crutch is adjusted in such a way that elbow is in 30° of flexion by keeping the hand on Handpiece of crutch.
  - Place the crutch tip 15 cm lateral and front to the toe.
  - The distance between top of forearm cuff and elbow flexion crease should 5 cm.

GUTTER CRUTCH (FIG. 43.6)

- This is a custom-made crutch in which elbow is kept flexed in 90° and whole forearm is used as weight transmitting surface. These are indicated in:

- Fixed flexion deformity at elbow joint
- Hand deformity with grip weakness

- *Parts of crutch:*
  - Tubular and adjustable shaft.
  - Well padded forearm trough
  - Handpiece
  - Rubber ferrule
- *How to hold the crutch:*
  - Height of crutch is adjusted in such a way that elbow is in 90° of flexion by keeping the forearm in trough.
  - Place the crutch tip 15 cm lateral and front to the toe.

WALKING STICKS (FIG. 43.7)

- Lighter walking aid but less stable.
- *Parts:*
  - Metallic tubular shaft.
  - Handle
  - Rubber tips
- *Length measurement:*
  - The highest point of stick lies at level of greater trochanter or radial styloid process.
  - *A unique method of length measurement of stick-steps are as:*
    - Hold walking stick without rubber tip
    - Place by side of patient sole with upside down of stick
    - Lower end of stick should be at level of most prominent part of greater trochanter or radial styloid process
    - Recapping the rubber tip and reverse the walking sticks.
- *How to hold the walking stick:* Height of stick is maintained in such a way that elbow is in 30° of flexion.
- *In which hand stick should be used:* In case of hip pathology stick should be used in contralateral hand
  - It wideness the base of support.
  - It reduces the stress over affected hip.

TRIPOD AND QUADRIPOD WALKING AID (FIG. 43.8)

- More stable than normal walking stick.
- Three or four legged platform.
- *Perfect candidate:* Elderly people.
- *Advantages:* Sticks stands upright beside the bed or chair.

CRUTCH GAIT

- There are four different patterns of Gait with crutches.
  1. Swinging crutch gait
  2. 4 Point gait
  3. 3 Point gait
  4. 2 Point gait
- *Swing through gait:*
  - *Characteristics:*
    - Weight bearing on both feet
    - Require stability and arm strength
    - Most advanced gait (fastest)

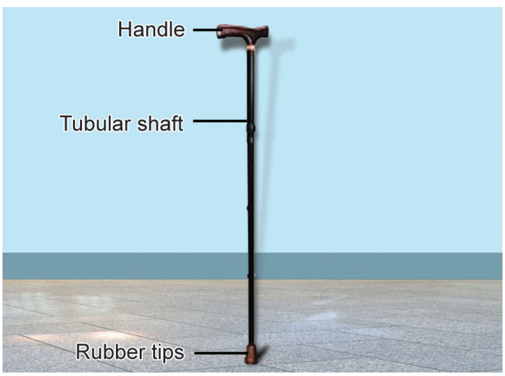


Fig. 43.7 Walking sticks

Fig. 43.8 Tripod and quadripod walking aid

- *Gait pattern:*
  - Advance both crutches
  - Lift both feet
  - Swing forward
  - Land both feet in front of crutches
  - Repeat sequence.
- *Swing to gait:*
  - *Characteristics:*
    - Weight bearing on both feet
    - Require stability and arm strength
    - Faster gait.
  - *Gait pattern:*
    - Advance both crutches
    - Lift both feet
    - Swing forward but not past the crutches
    - Repeat the sequence.
- *4 Point gait:*
  - *Characteristics:*
    - Partial weight bearing on both feet.
    - Maximal support by crutches.
    - Constant shift of weight over points.
  - *Gait pattern:*
    - Advance right crutch
    - Advance left foot
    - Advance left crutch
    - Advance right foot
    - Repeat sequence.
- *3 Point gait:*
  - *Characteristics:*
    - Require good balance and arm strength.
    - One foot—nonweight bearing.
    - Faster gait.
  - *Gait pattern:*
    - Lift both crutches and weaker lower limb together
    - Advance stronger lower limb
    - Repeat sequence.
- *2 Point gait:*
  - *Characteristics:*
    - Partial weight bearing on both feet.
    - Minimum crutch support.
    - Faster than 4 point gait.
  - *Gait pattern:*
    - Advance left foot and right crutch
    - Advance right foot and left crutch
    - Repeat sequence.
- *Tripod crutch Gait:*
  - *Characteristics:*
    - Initial pattern for paraplegic person learning swing to gait.
    - High energy consumption.
  - *Gait pattern:*
    - Advance left crutch
    - Advance right crutch
    - Drag both feet to the crutches
    - Repeat sequence.

SECTION

5

Table of Bone, Joint Model and Specimen

Upendra Kumar

Chapters

- Basics about Bones and Joints
- Bone and Joints of Upper Limb
- Bones and Joints of Lower Limb
- Bones and Joints of Spine
- Specimen Section

BONE AND JOINT SECTION

Proceeding for Bone and Joint Section

- Examiner may ask please pick-up a bone or joint model
- Now wait for examiner question

Examiner Expectations from Bone and Joint Models

- Bone and joint identification?
- Side determination and parts of bone?
- Muscle and ligament attachment?
- Ossification center of bone?
- Compartments of limb?
- Joints type?
- Capsular attachment?
- Ligaments around joint?
- Movements around joint?
- Any point of orthopedic significance?

CHAPTER

44

Basics about Bones and Joints

COMPOSITION OF BONE

- Bone is specialized connective tissue.
- *Composition:*
  - Water (10%)
  - *Organic matrix (osteoid)(25%):* Provides flexibility and resilience
    - *Proteins:* Type 1 collagen, proteoglycans, osteocalcin, osteonectin, osteopontin
    - *Cells:* Osteoblasts, osteoclasts, osteocytes
  - *Inorganic elements (65%):* Provides hardness and brittleness
    - Hydroxyapatite $[Ca_{10}(PO_4)_6(OH)_2]$
    - Ratio of calcium to phosphorus in bone is 2:1.

PARTS OF BONES (FIG. 44.1)

- Articular cartilage
- Epiphysis
- Growth plate (physis)
- Metaphysis

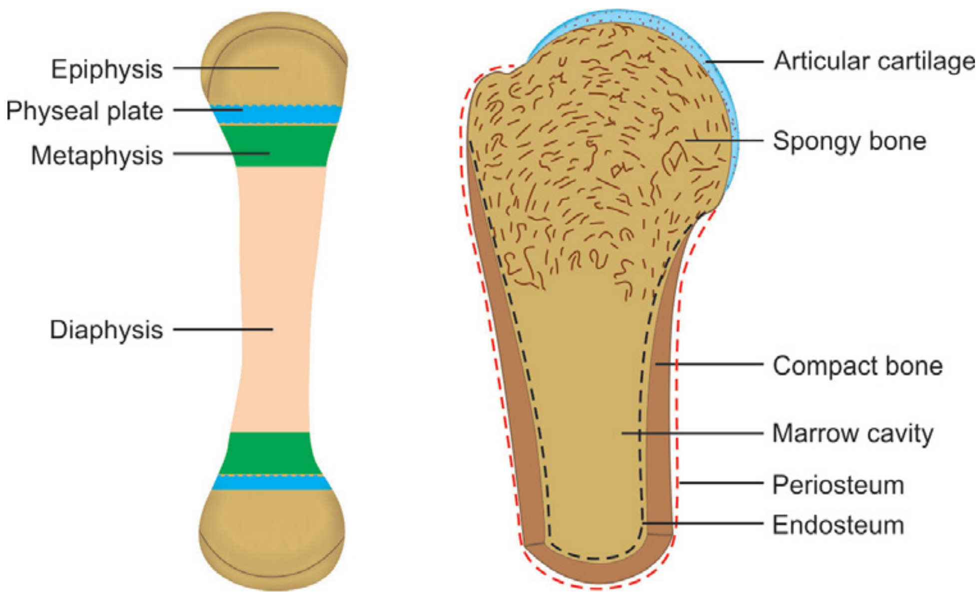


Fig. 44.1 Parts of bones
(*Courtesy:* Inderbir Singh's Textbook of Human Histology)

- Diaphysis
- Medullary cavity
- Cortex (compact bone)
- Cancellous bone (spongy bone).

BLOOD SUPPLY OF LONG BONE (FIG. 44.2)

- *Vasculatures are:*
  - *Nutrient artery:* Ascending and descending medullary vessels
  - Periosteal vessels
  - Epiphyseal vessels

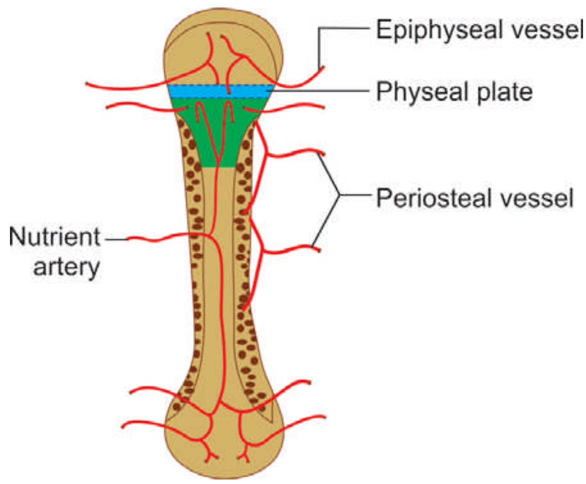


Fig. 44.2 Blood supply of long bone (*Courtesy:* Inderbir Singh's Textbook of Human Histology)

- *Cortical blood supply:*
  - Outer 1/3rd of cortex—periosteal vessels
  - Inner 1/3rd of cortex—medullary vessels.

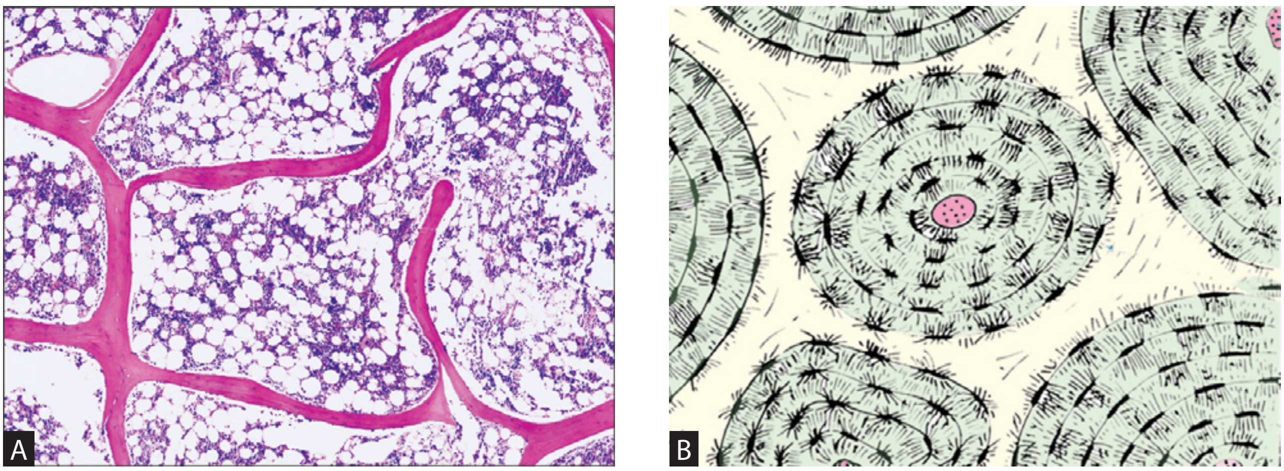
PERIOSTEUM OF BONE

- Periosteum covers majority of bony structures except articular surface and sesamoid bone.
- *Layers of periosteum:*
  - Outer fibrous layer
  - *Inner cambium layer*: Cellular layer, contains osteoprogenitor cells, role in appositional bony growth and fracture healing.

DEVELOPMENTAL (MICROSCOPIC) CLASSIFICATION OF BONE (FIGS 44.3A AND B)

Comparison between woven bone and lamellar bone

Woven bone	*Lamellar bone*
Randomly arranged collagen, i.e. wavy appearance of fibrous matrix	Orderly arranged collagen sheet like arrangement
Not stress oriented	Stress oriented
Weaker and more flexible	Stronger and less flexible
Seen in fetal skeleton, healing fracture (callus) and Paget's disease	For example, all adult bone, hard callus.



Figs 44.3A and B (A) Woven bone; (B) Lamellar bone (*Courtesy:* Inderbir Singh's Textbook of Human Histology)

ADULT BONE CLASSIFICATION

- An adult bone is divided in two groups
  1. *Cortical bone:* Lamellae are densely packed and they are also called compact bone.
  2. *Cancellous bone:* Lamellae are loosely packed and they are also called trabecular bone.
- *Osteon (Haversian system):* Structural unit of bone. Its component are as (Fig. 44.4)
  - Lamellae:
    - Circumferential
    - Concentric
    - Interstitial
  - *Lacunae:* Small spaces
  - *Periosteum:*
    - Fibrous—outer layer
    - Cambium—inner layer; absent in neck femur
  - Endosteum
  - *Canaliculi:* Radiating channels connecting lacunae
  - Haversian canals
  - Volkmann's canal.

GROWTH PLATE (PHYSIS): CONVENTIONALLY CALLED EPIPHYSEAL PLATE (FIG. 44.5)

Zone of physis, their function and disease		
Physeal zones	*Function*	*Disease*
Resting zone	Quicescent chondrocyte	• Gaucher's disease • Diastrophic dysplasia
Zone of proliferation	Rapidly dividing chondrocytes	• Achondroplasia • Multiple hereditary exostosis
Zone of hypertrophy	Cell hypertrophy and calcium accumulation	• SCFE • Rickets • Multiple epiphyseal dysplasia
Zone of provisional calcification	Release of calcium by apoptotic chondrocyte	• SCFE • Rickets • Multiple epiphyseal dysplasia
Zone of ossification	Mineralization of matrix	Scurvy

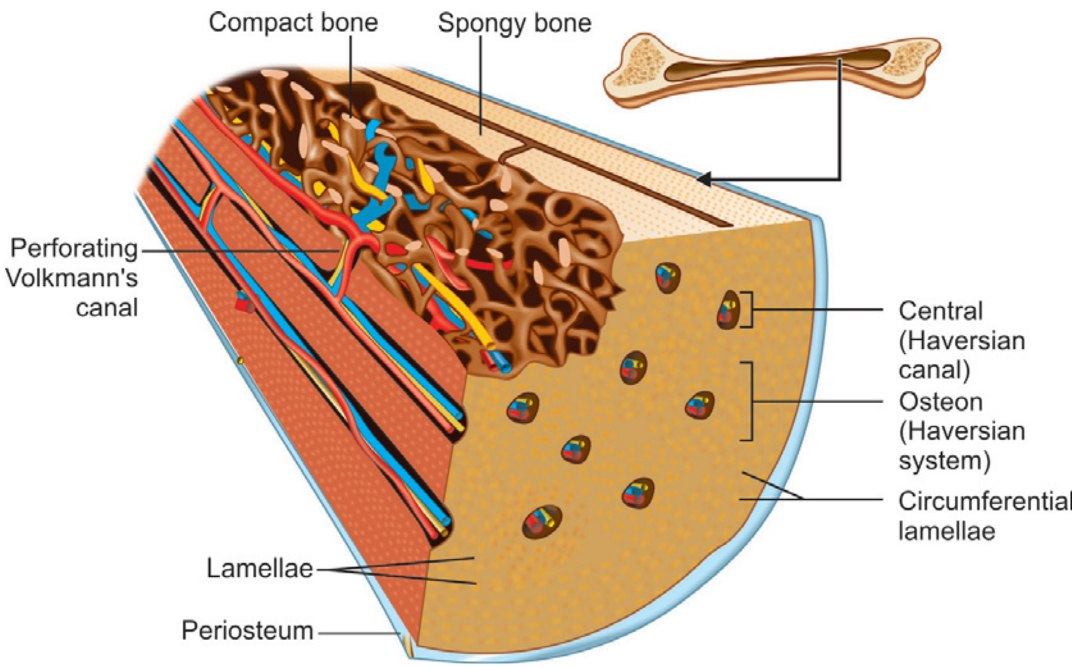


Fig. 44.4 Osteon (Haversian system)

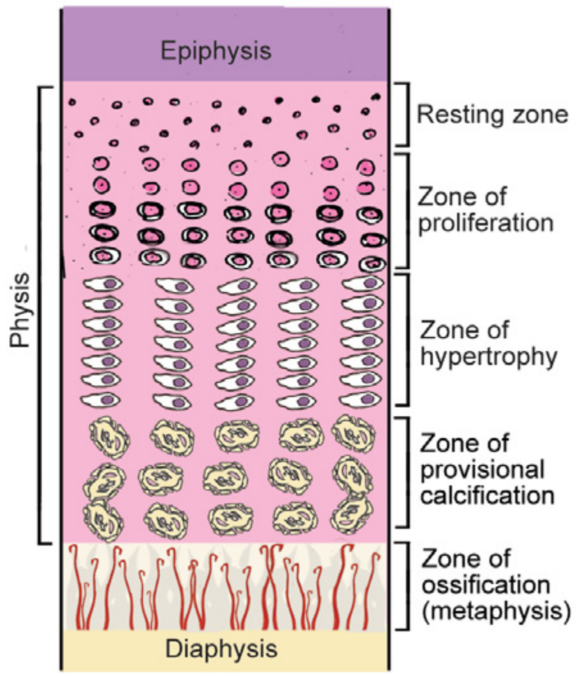


Fig. 44.5 Layers of physis

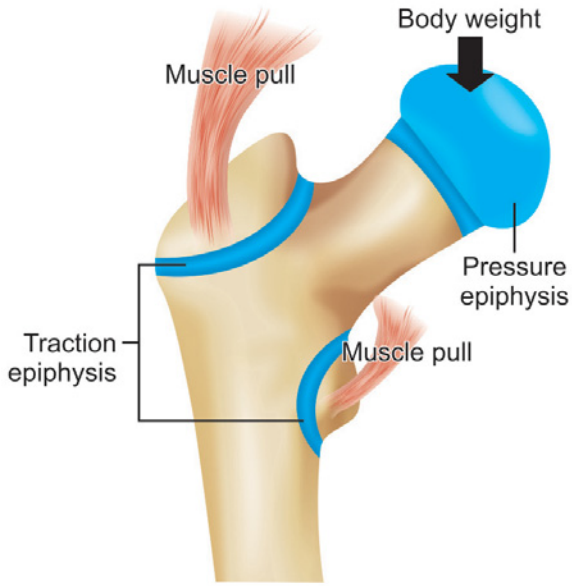


Fig. 44.6 Pressure and traction epiphysis

- *Blood supply of physis:*
  - Epiphyseal vessels
  - Metaphyseal vessels
  - Periosteal.

TYPES OF EPIPHYSIS (FIG. 44.6)

- *Pressure epiphysis:* Remains under continuous load and forms joints like head of femur, head of humerus, etc.
- *Traction epiphysis:* Supporting ligaments and tendons are attached to them, e.g. greater trochanter of femur, greater tuberosity of humerus.
- *Atavistic epiphysis:* Phylogenetically they are separate bones but in human skeleton they lose their identity and fused with other bones. For example, coracoid process of scapula.
- *Aberrant epiphysis:* That normally not present in the bone. For example, head of first metacarpal bone.

☑ *Note:* Osteochondritis may develop in pressure epiphysis and traction epiphysis.

BONE FORMATION AND GROWTH PATTERN (FIGS 44.7A AND B)

- *Two ossification center:*
  1. Primary ossification center
  2. Secondary ossification center
- *Primary ossification center:*
  - First area of bone to start ossifying.
  - It usually appears in prenatal period.
  - It leads to formation of diaphysis or shaft of long bone.
  - Its number is generally one.
- *Secondary ossification center:*
  - Appear after appearance of primary ossification center.
  - It appears during postnatal and adolescent period.
  - It leads to formation of end of the long bone like epiphysis.
  - Its number are usually more than one.
- *Two methods of bone formation are:*
  - Endochondral ossification:
    - Here replacement of cartilage model by bone.
    - Most long bones develop by endochondral ossification, e.g. vertebrae, pelvis, and skull base bones also.

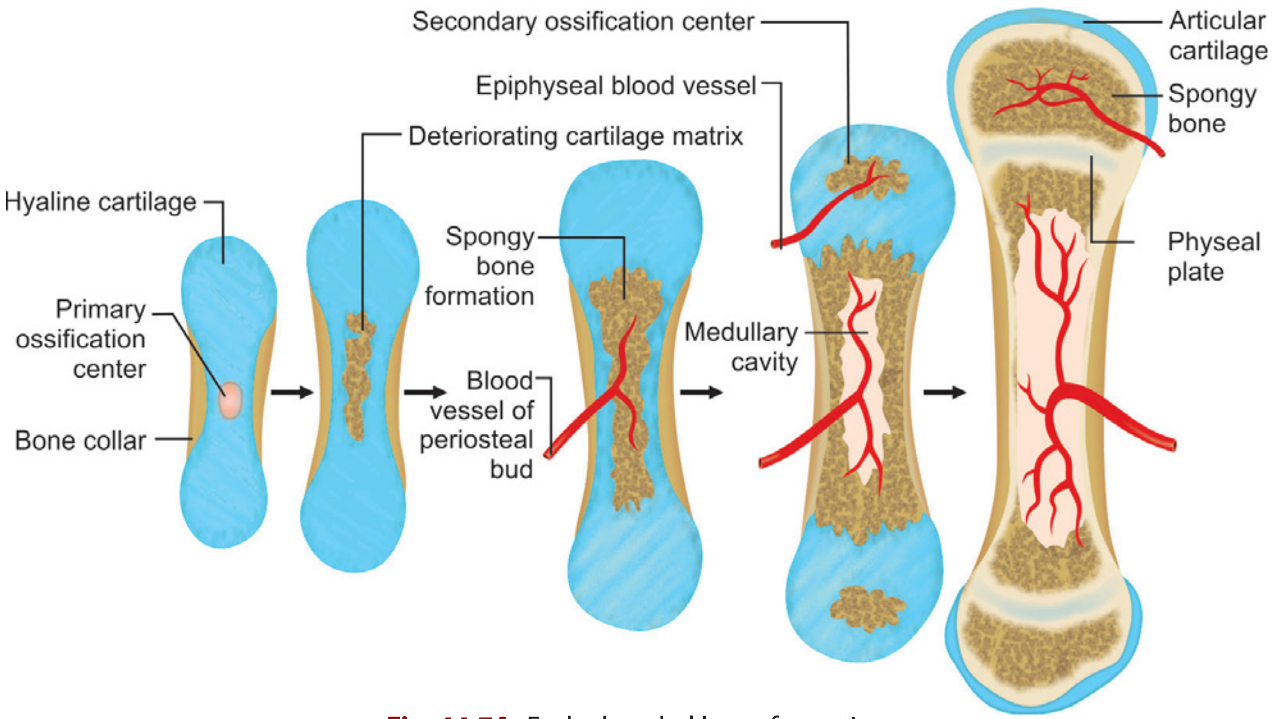


Fig. 44.7A Endochondral bone formation
(*Courtesy:* Inderbir Singh's Textbook of Human Histology)

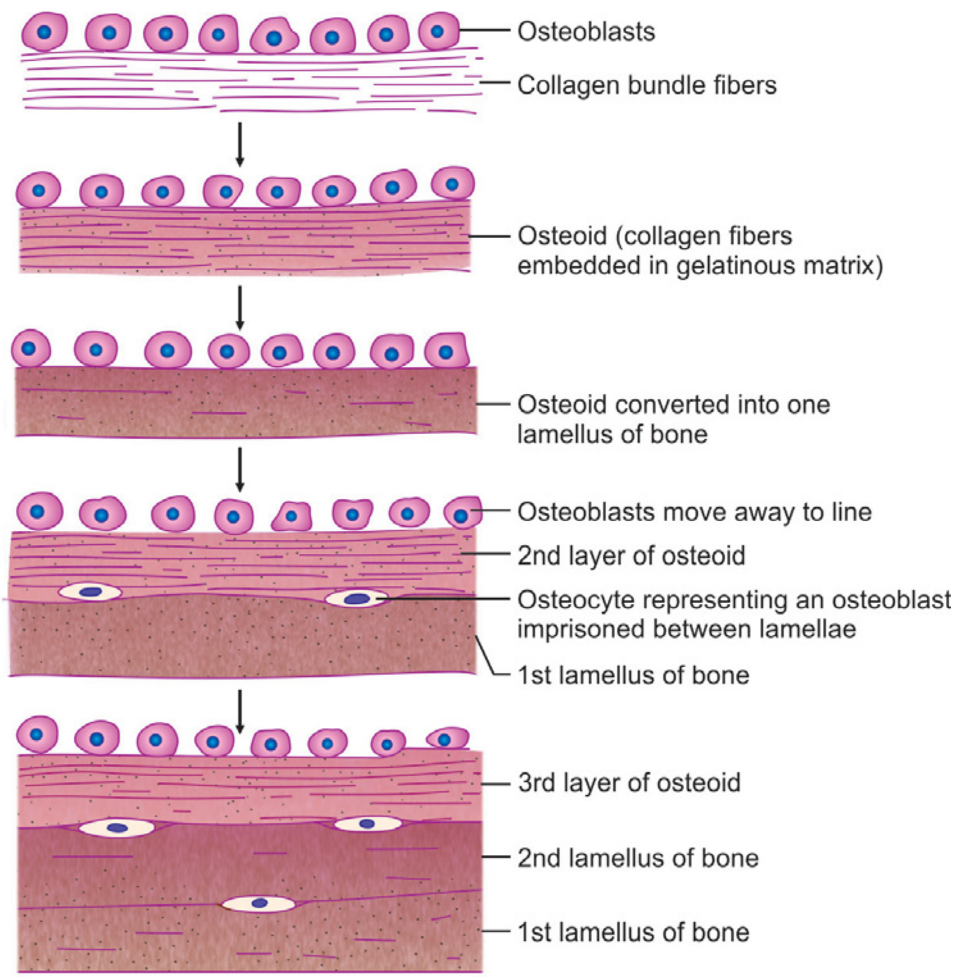


Fig. 44.7B Intramembranous bone formation
(*Courtesy:* Inderbir Singh's Textbook of Human Histology)

- It is interstitial growth that increases the length of bone.
- Intramembranous ossification:
  - Here direct bone formation from mesenchymal tissue.
  - For example, clavicle, mandible and skull vault.
  - It is appositional growth that increases the width of bone.

NORMAL BONE TURNOVER

	Bone modeling	*Bone remodeling*
When	During development and during early fracture healing	After maturation and late stages of fracture healing
How	Independent action of osteoblasts and osteoclasts	Coordinated action of osteoblast and osteoclast
Where	Resorption and formation at different sites—resorption at tensile surface and formation at compression surface	At same site
What it does	Changes the bony structure	Maintains the bony structure

FRACTURE HEALING

- *Direct or primary healing:*
  - No external callus formation
  - Occur mainly after rigid internal fixation.
  - *By cutting cones mechanism*: Osteoclast cones followed by osteoblast around leash of blood vessels (Fig. 44.8A).
- *Indirect or secondary healing:*
  - External callus formation occur
  - Natural healing or less rigid fixation.
  - *Stages of fracture healing by callus formation:* (Fig. 44.8B)
    - Stages of hematoma formation and inflammation.

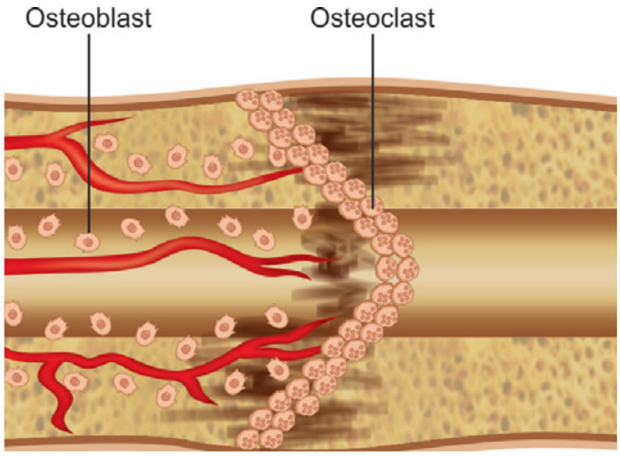


Fig. 44.8A Cutting cones mechanism

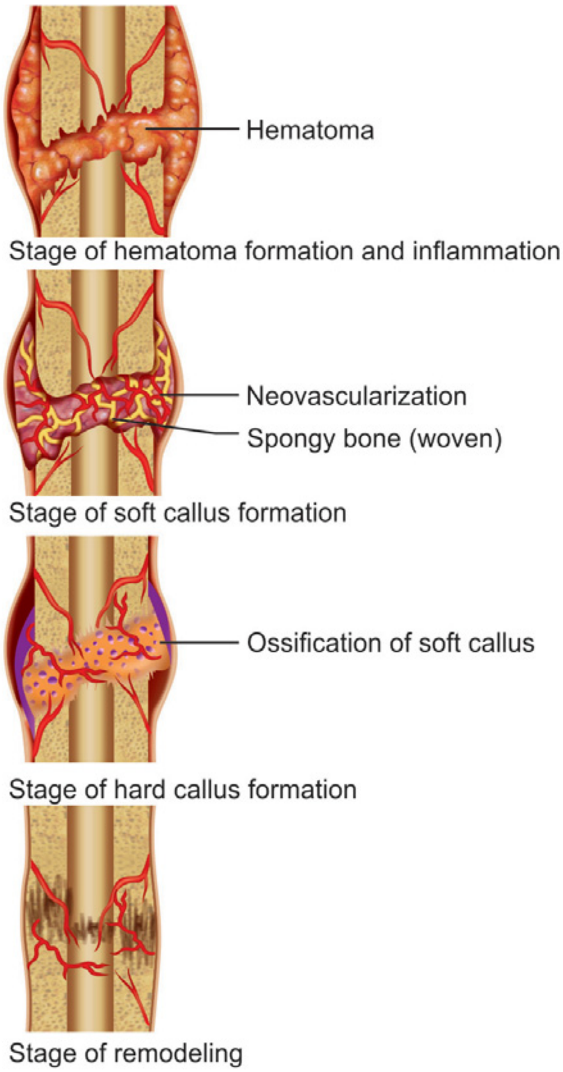


Fig. 44.8B Stages of fracture healing

- Stage of soft callus.
- Stage of hard callus.
- Stage of remodeling.

JOINT

The point at which two or more bones meet is called joint.

CLASSIFICATION OF JOINT

- *Fibrous joint (synarthrosis):* Here two bones are connected by fibrous connective tissue and there is no movement at this joint (Fig. 44.9).

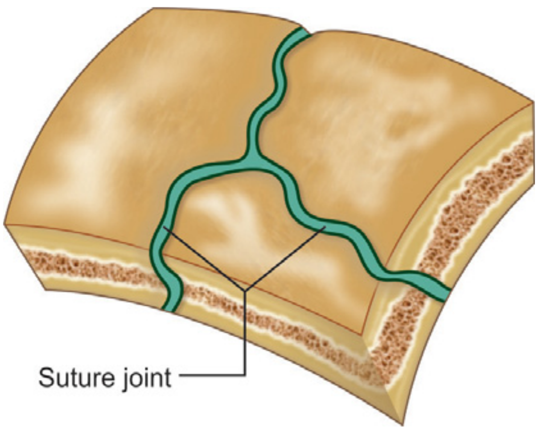


Fig. 44.9 Fibrous joint (synarthrosis), e.g. suture joint in skull
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

  - *Suture joint:* For example, skull.
  - *Gomphosis joint:* For example, teeth and socket.
  - *Syndesmosis:* For example, inferior tibio-fibular joint
- *Cartilaginous joint (amphiarthrosis):* Here two bones are connected by a cartilage and there is slight movement at this joint (Figs 44.10A and B).
  - *Primary cartilaginous (synchondrosis):* Here hyaline cartilage is present in between the joint, e.g. costochondral joint between ribs and sternum, 1st chondrosternal joint.
  - *Secondary cartilaginous (symphysis)*: Here fibrous cartilage is present in between the joint, e.g. pubic symphysis, intervertebral disc.
- *Synovial joint (diarthrosis):* Here two bone ends are connected by a fibrous joint capsule that contain synovial fluid and there is maximum mobility at this joint (Fig. 44.11).
  - *Feature of a typical synovial joint:*
    - Two articulating bone
    - Hyaline cartilage over articulating surfaces
    - Synovium—overlies the joint cartilages
    - Synovial fluid—joint lubricant, a source of nutrition and secreted by synovial cells (type II)
    - Joint capsule—provide coverage to joint.

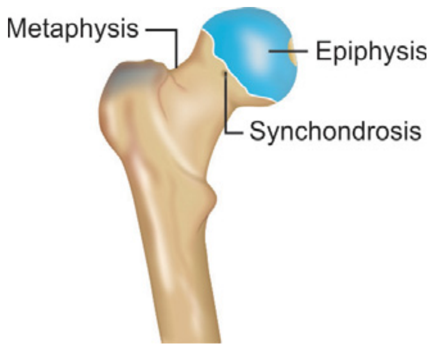


Fig. 44.10A Primary cartilaginous (synchondrosis) in femoral neck
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

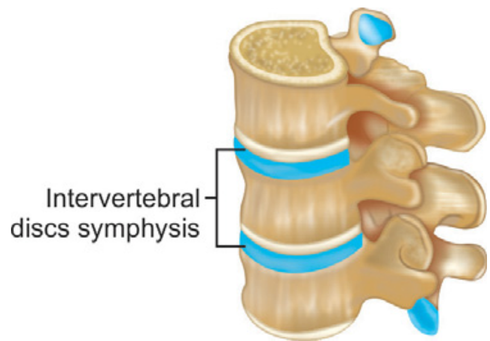


Fig. 44.10B Secondary cartilaginous (symphysis) in spine
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

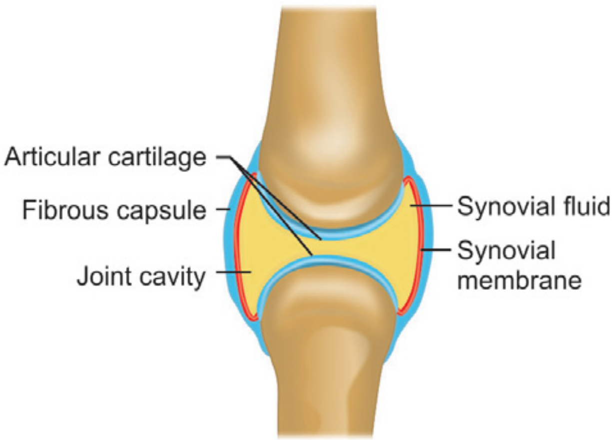


Fig. 44.11 Synovial joint (diarthrosis)
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

– *Various types of synovial joint:*

• *Hinge joint:* For example, humeroulnar joint
• *Pivot joint:* For example, superior radioulnar joint
• *Ball and socket joint:* For example, hip joint
• *Plane or gliding joint:* For example, intercarpal, intertarsal, facet joint of spine
• *Ellipsoidal joint:* For example, radiocarpal joint
• *Saddle joint:* For example, 1st carpometacarpal joint
• *Bicondylar or condylar joint:* For example, knee joint, metacarpophalangeal joint

FUNCTIONS OF JOINT

- Movement of the part, e.g. limbs
- Stability of the part, e.g. skull
- Weight bearing, e.g. lower limb.

CHAPTER

45

Bones and Joints of Upper Limb

CLAVICLE

- *Morphology of clavicle (Fig. 45.1)*:
  - *Border and surfaces:*
    - Lateral 1/3rd—anterior and posterior border and superior and inferior surface.
    - Medial 2/3rd—anterior, posterior, superior and inferior surfaces.
- *Attachments over clavicle (Fig. 45.2)*:
- *Ossification center:*
  - *Primary:* 2
  - *Secondary:* 1 (medial end)
  - *Fusion of physis:* 21–22 years.

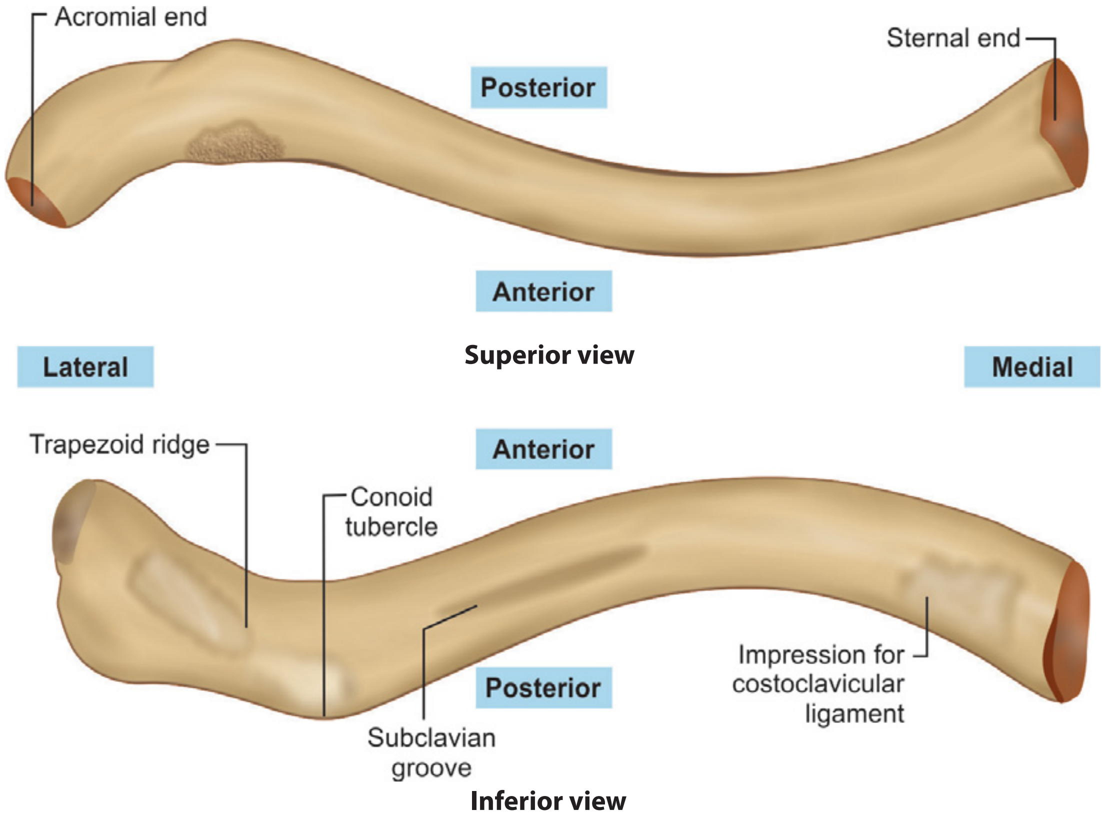


Fig. 45.1 Morphology of clavicle
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Muscles connecting clavicle with axial skeleton:*
  - *With skull and spine:*
    - Sternocleidomastoid
    - Trapezius
  - *With rib cage:*
    - Pectoralis major
    - Subclavius.
- *Points of orthopedic significance:*
  - Only long bone that lies horizontally.
  - Subcutaneous throughout.
  - First bone to start ossifying (but last to fuse).
  - Only long bone with membranous ossification.
  - Only long bone with two primary centers of ossification.
  - Generally said to have no medullary cavity, not always true.
  - Occasionally pierced by middle supraclavicular nerve.
  - Only long bone connecting the axial to appendicular skeleton.

SCAPULA

- *Morphology of scapula (Fig. 45.3)*:
  - *Border of scapula and surfaces:*
    - Border—medial border, lateral border and superior border
    - Surfaces—costal surface and dorsal surface.

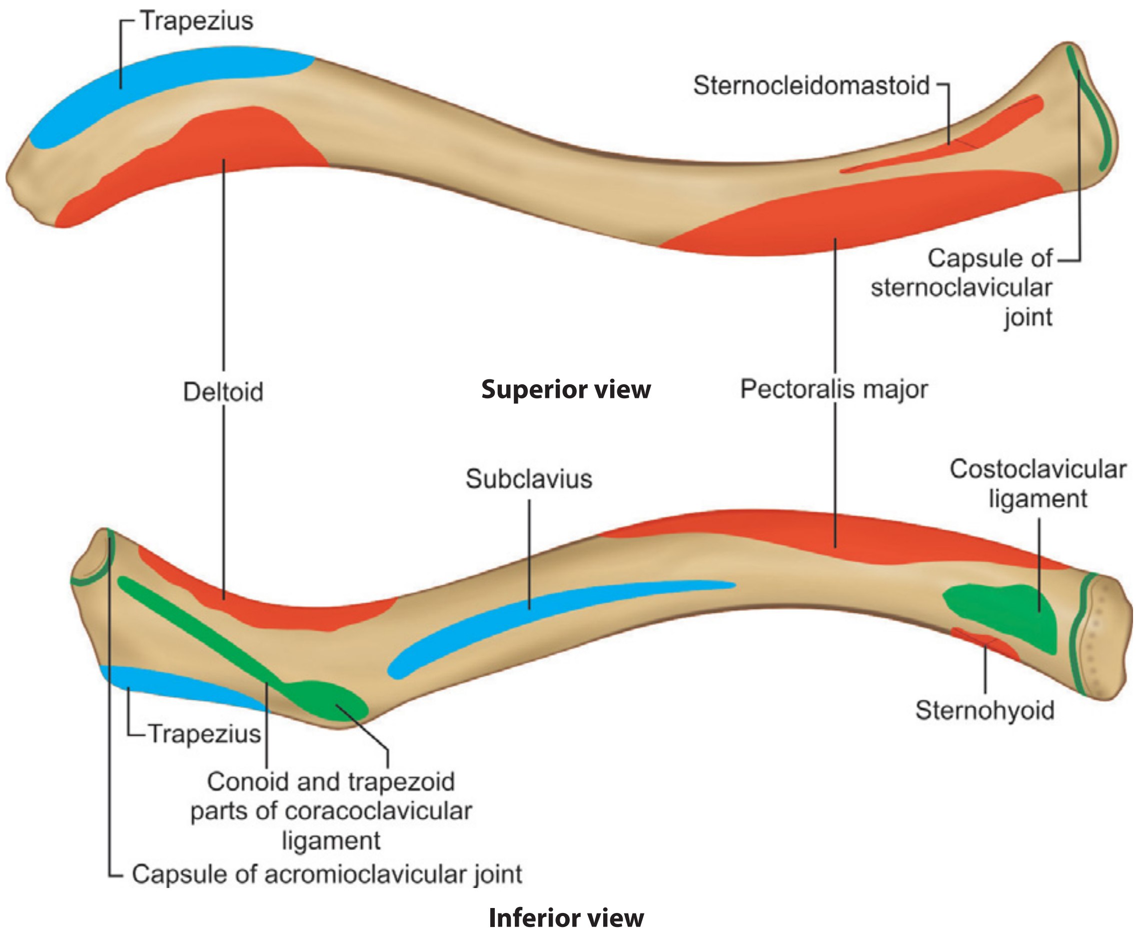


Fig. 45.2 Attachments over clavicle
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Attachments over scapula (Fig. 45.4)*:
- *Ossification center:*
  - *Primary:* 1
  - *Secondary:* 7
- *Muscle that connect scapula with axial skeleton:*
  - With spine
    - Levator scapulae
    - Rhomboid minor
    - Rhomboid major
    - Latissimus dorsi
    - Trapezius.
  - With rib cage:
    - Pectoralis minor
- *Points of orthopedic significance:*
  - *Suprascapular notch:*
    - Covered by transverse suprascapular ligament.
    - Suprascapular vessels run above this ligament.

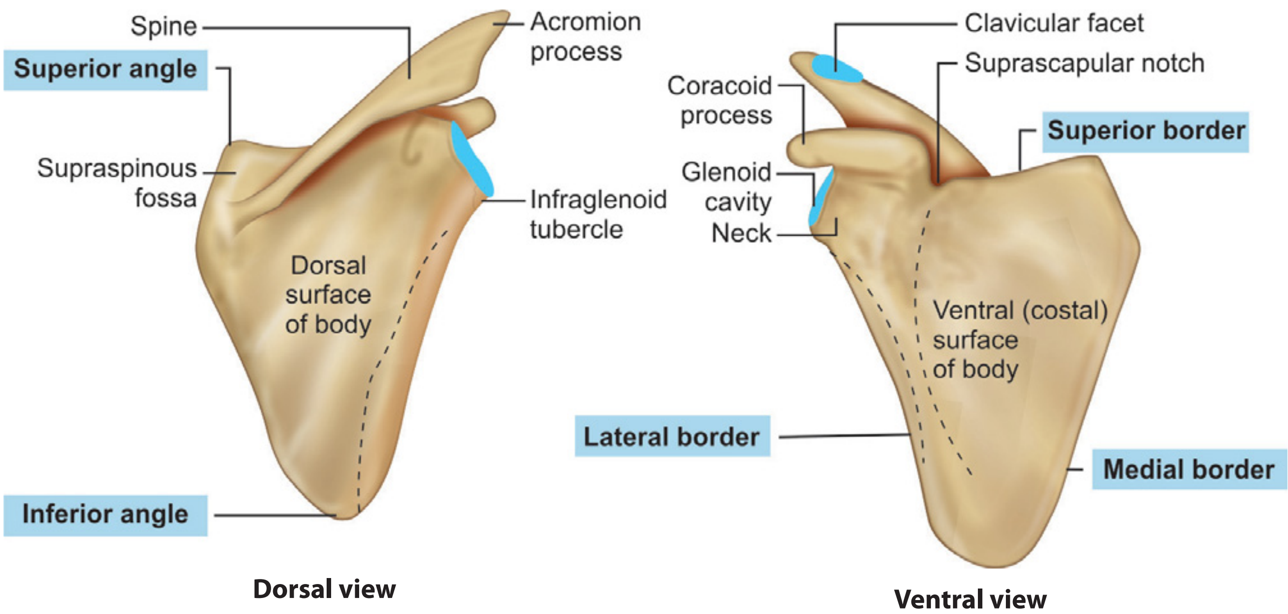


Fig. 45.3 Morphology of scapula
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

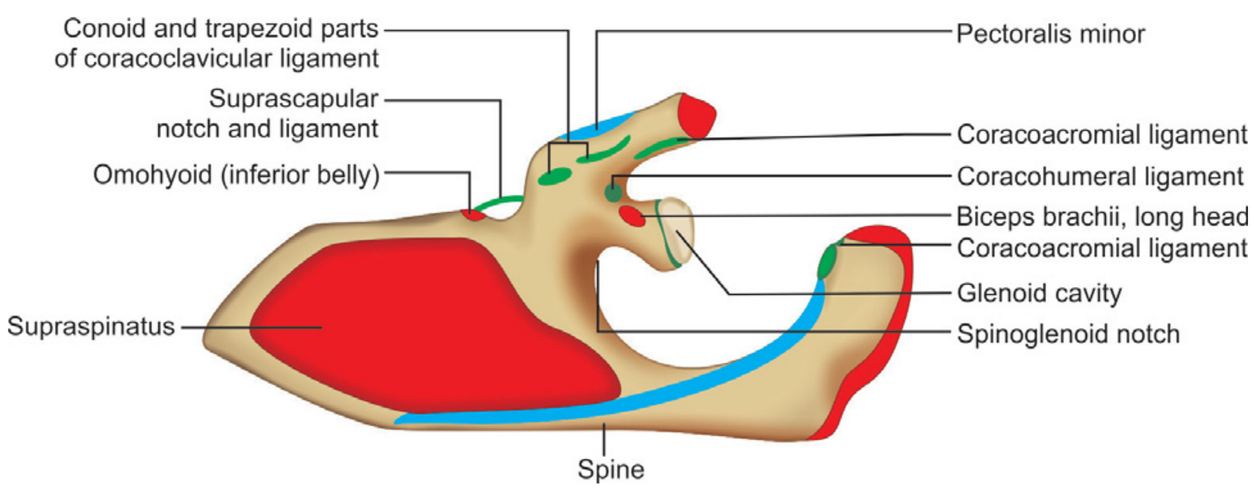


Fig. 45.4

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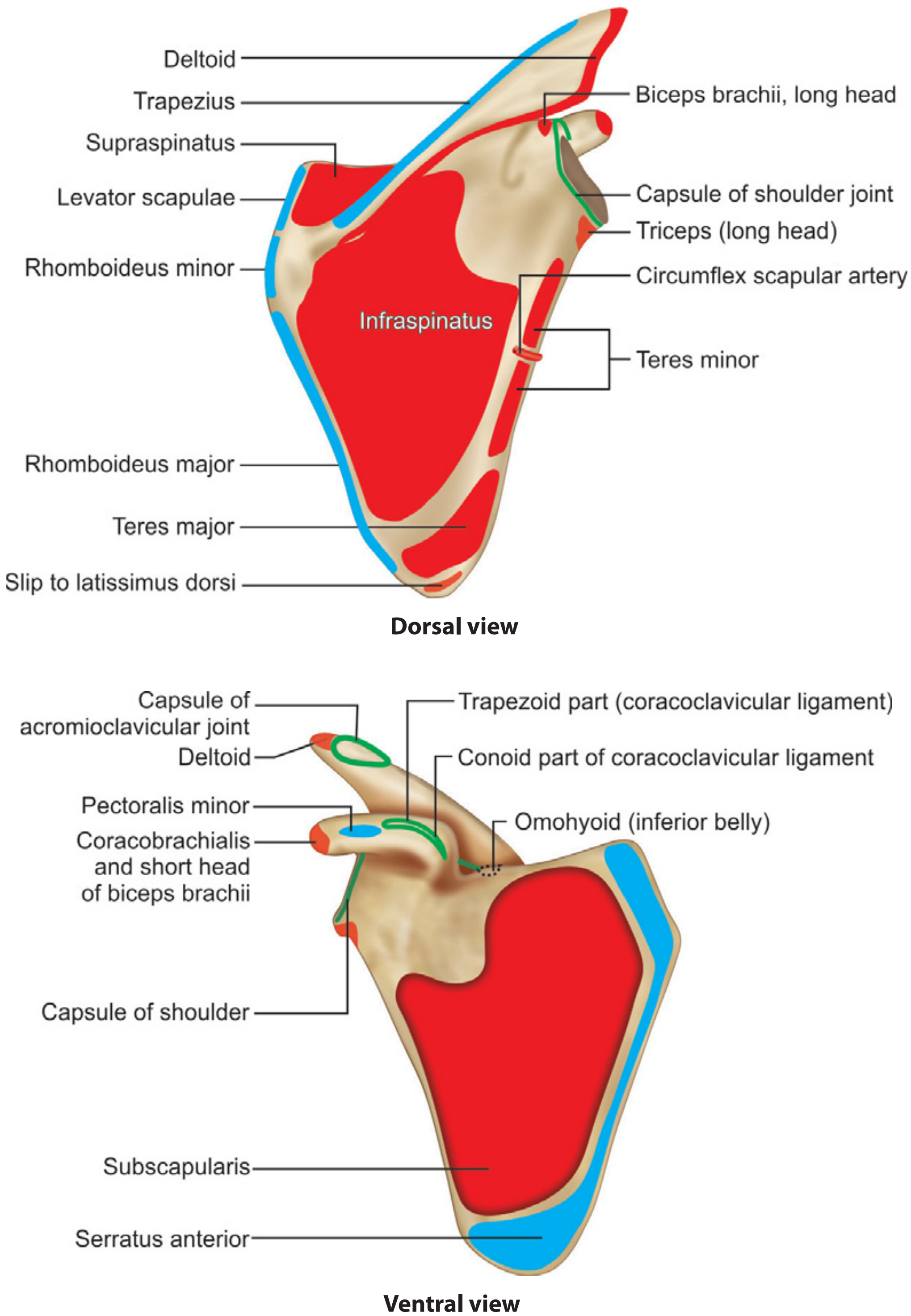


Fig. 45.4 Attachments over scapula
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- Suprascapular nerve passes below this ligament.

– *Spinoglenoid notch:*
- Covered by spinoglenoid ligament.
- Suprascapular nerves and vessels pass through it.
- Its compression leads to suprascapular impingement syndrome.

HUMERUS

- *Morphology of humerus (Fig. 45.5)*:
  - *Border and surfaces of shaft:*
    - Border—Anterior, medial and lateral border
    - Surfaces—Anteromedial, anterolateral and posterior surface.
- *Attachments over humerus (Fig. 45.6)*:
- *Ossification center:*
  - *Primary:* 1
  - *Secondary:* 3 upper end and 4 lower end
  - *Time of appearance of upper end ossification center:*
    - Head of humerus—1 year
    - Greater tuberosity—2 years
    - Lesser tuberosity—5 years
  - *Fusion of physis:*
    - Upper end—20 years
    - Lower end—16 years, except medial epicondyle 20 years.
- *Compartment of arm:* Medial and lateral intermuscular septum (Fig. 45.7).
  - *Flexor compartment:*
    - Biceps-brachii
    - Brachialis
    - Coracobrachiolis—sometimes called medial compartment muscle.
  - *Extensor compartment:*
    - Triceps—long head
    - Triceps—lateral head
    - Triceps—medial head.
- *Points of orthopedic significance:*
  - *Angle of retroversion of head of humerus:* 20°–40° (average 30°).
  - *Humeral head shaft angle:* 135°.
  - *Surgical neck:* It connects diaphysis with proximal humerus, related to axillary nerve.
  - *Anatomical neck:* It is boundary line between articular surface of head and rest of proximal humerus. It corresponds to synovial attachment.

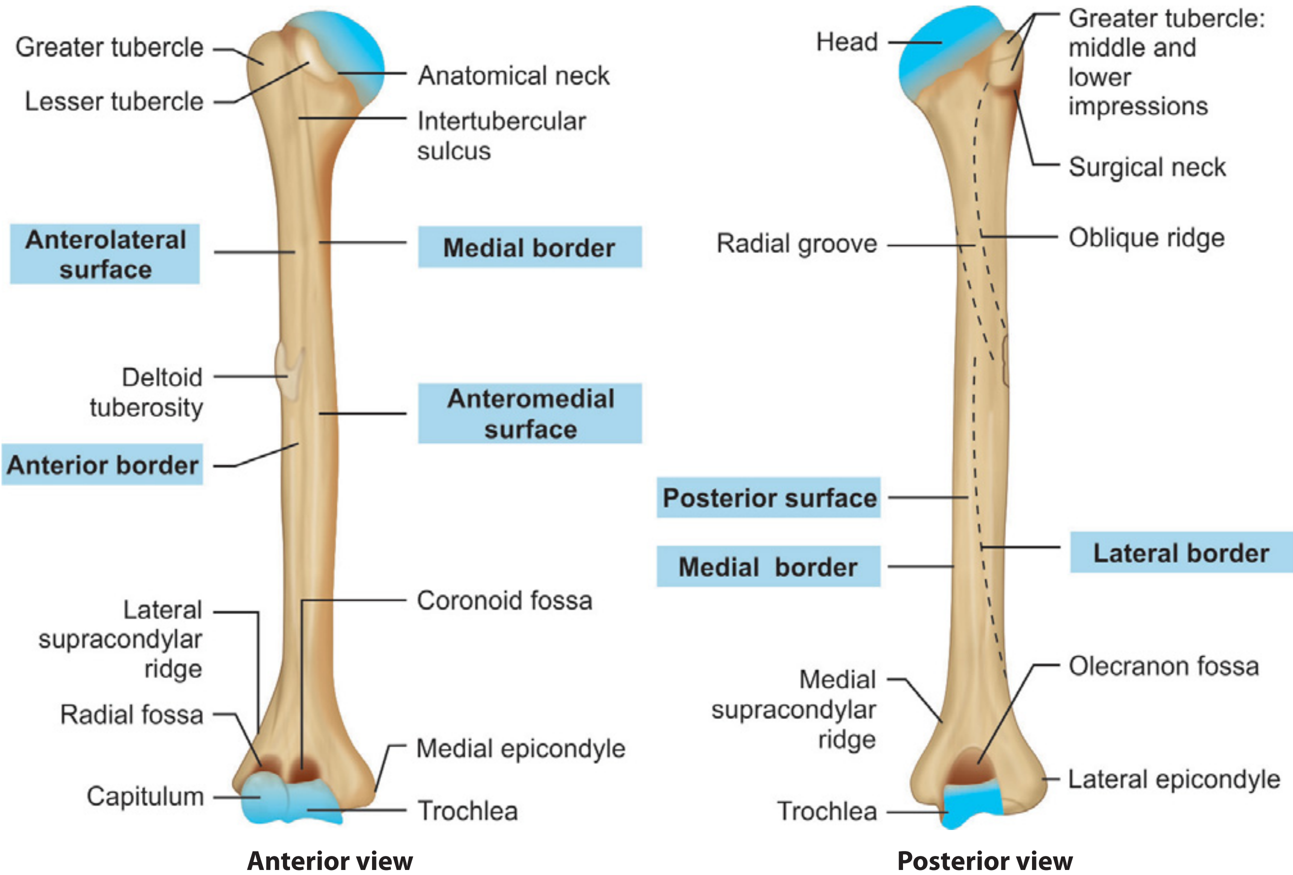


Fig. 45.5 Morphology of humerus
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Content of bicipital groove:* Long head of bicep brachii and ascending branch of anterior circumflex humeral artery.
- *Content of radial groove:* Radial nerve and profunda brachii vessels.
- *Content of ulnar groove:* Ulnar nerve.
- *Trochlear edges:* The medial edge of trochlea projects down 6 mm more than lateral edge.
- *Blood supply of head of humerus* (Fig. 45.8):
  - *By third part of axillary artery:*

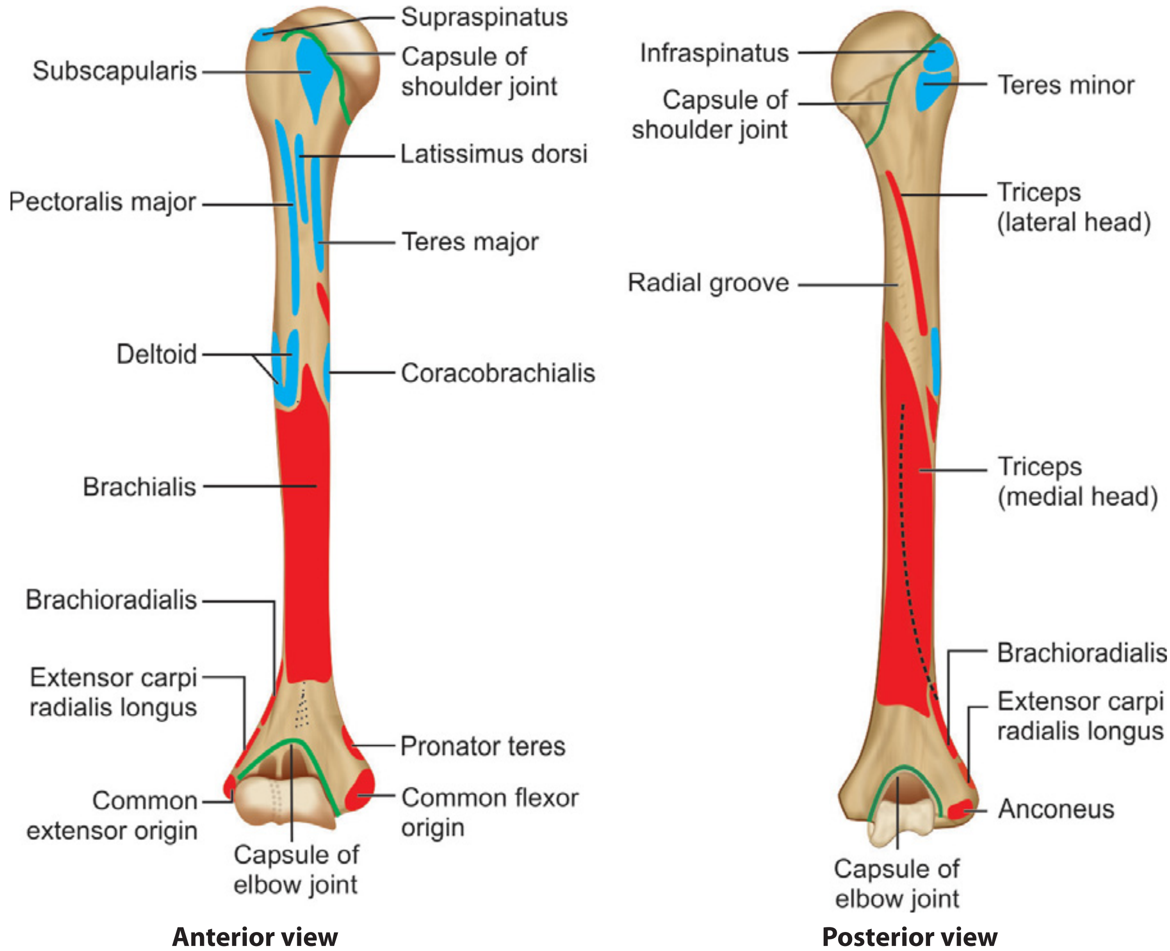


Fig. 45.6 Attachments over humerus
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

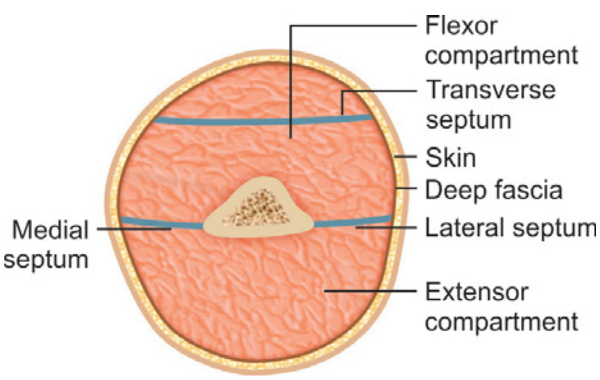


Fig. 45.7 Compartment of arm

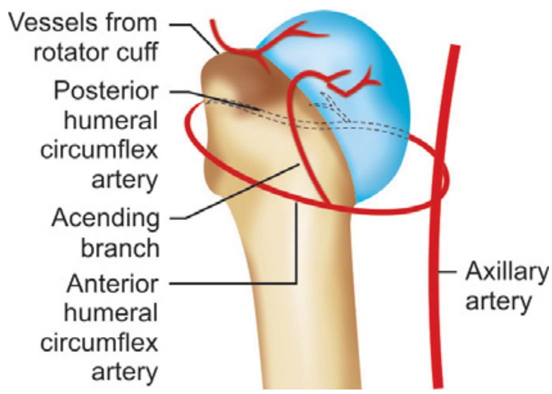


Fig. 45.8 Blood supply of head of humerus

- *Anterior circumflex humeral artery:* Ascending branch (arcuate branch)
- *Posterior circumflex humeral artery:* A small area in posteroinferior aspect of head

RADIUS AND ULNA

- *Morphology of radius and ulna (Fig. 45.9)*:
  - Border and surfaces of shaft
    - Border—anterior, posterior, interosseous borders
    - Surfaces—anterior, posterior, lateral (radius) and medial (ulna) surfaces.
- *Attachments over radius and ulna (Fig. 45.10)*:
- *Ossification center:*
  - *Primary:* 1 (radius) and 1 (ulna)

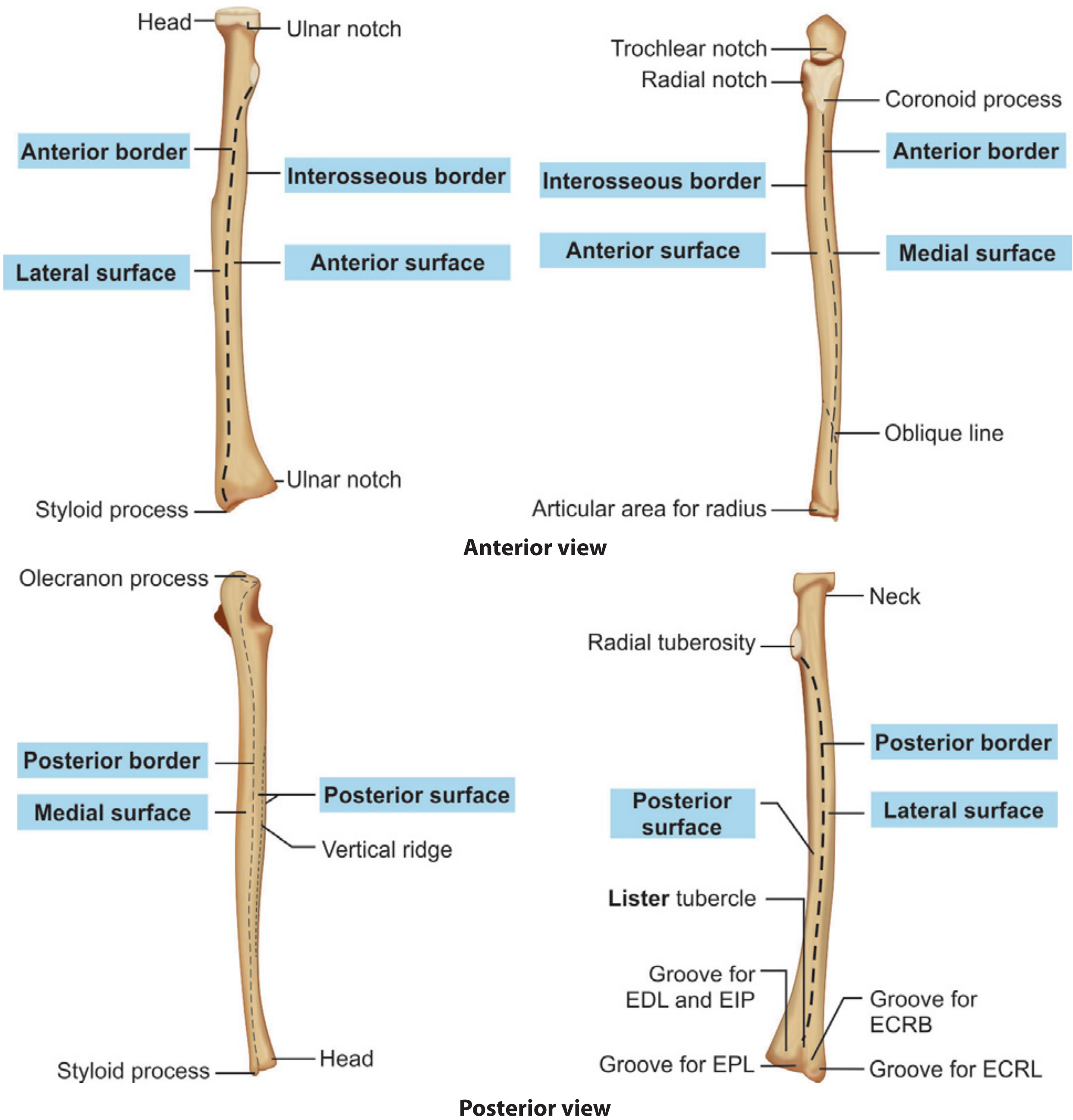


Fig. 45.9 Morphology of radius and ulna
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)
Abbreviations: ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; EDL, extensor digitorum longus; EIP, extensor indicis proprius; EPL, extensor pollicis longus

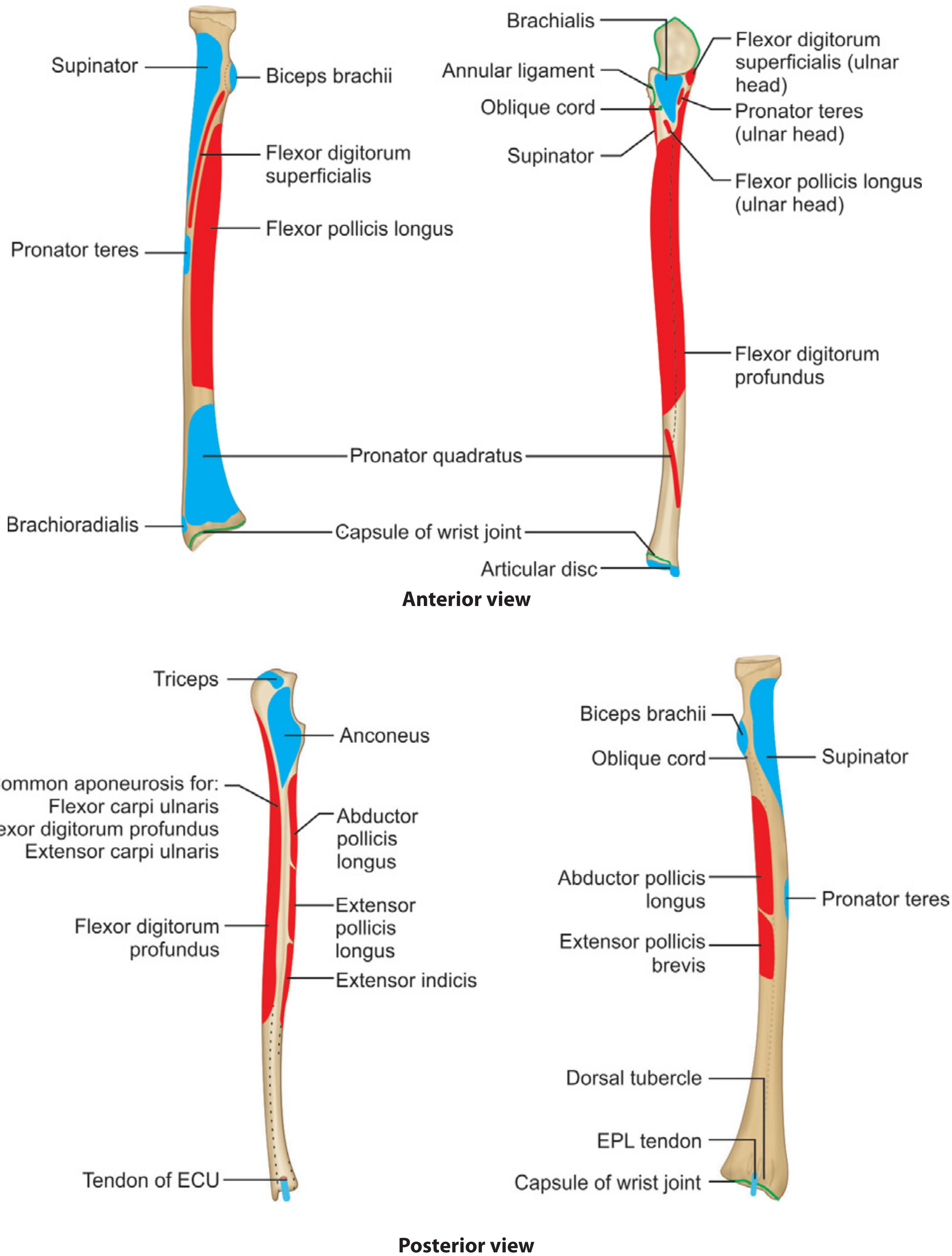


Fig. 45.10 Attachments over radius and ulna
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)
Abbreviations: ECU, extensor carpi ulnaris; EPL, extensor pollicis longus

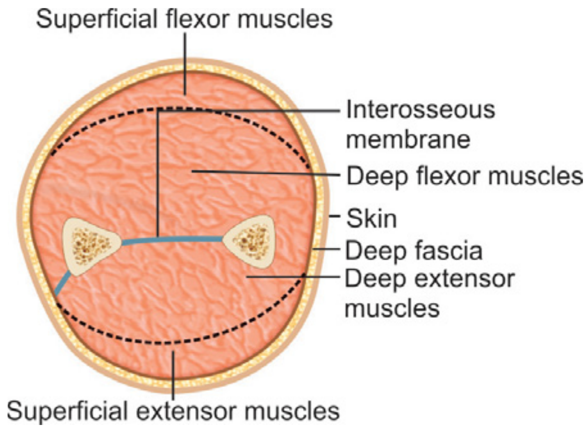


Fig. 45.11 Compartment of forearm

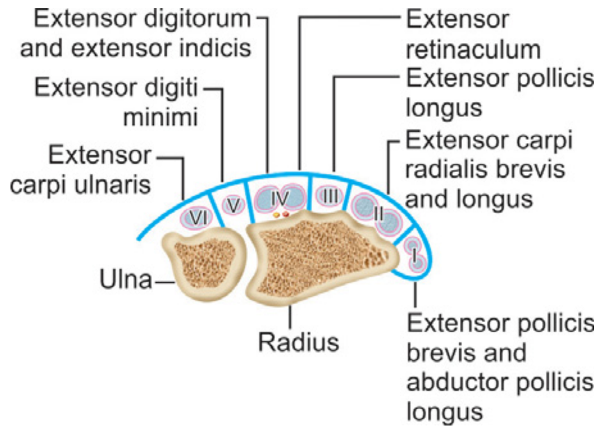


Fig. 45.12 Content of dorsal compartment of wrist

- *Secondary:* 2 (radius) and 2 (ulna), one in upper end and one in lower end.
- *Fusion of physis:*
  - Radius: 18 years at upper end and 20 years at lower end.
  - *Ulna:* 16 years at upper end and 18 years at lower end.

- *Compartment of forearm (Fig. 45.11)*:
  - Interosseous membrane
  - *Flexor compartment:* Five superficial muscles
    1. Pronator teres
    2. Flexor carpi radialis
    3. Palmaris longus
    4. Flexor carpi ulnaris
    5. Flexor digitorum superficialis
  - *Flexor compartment:* Three deep muscles
    1. Flexor digitorum profundus
    2. Flexor pollicis longus
    3. Pronator quadratus
  - *Extensor compartment:* Seven superficial muscles
    1. Anconeus
    2. Brachioradialis
    3. Extensor carpi radialis longus
    4. Extensor carpi radialis brevis
    5. Extensor digitorum (communis)
    6. Extensor digiti minimi
    7. Extensor carpi ulnaris.
  - *Extensor compartment:* Five deep muscles
    1. Supinator
    2. Abductor pollicis longus
    3. Extensor pollicis brevis
    4. Extensor pollicis longus
    5. Extensor indicis (proprius)

- *Points of orthopedic significance:*
  - *Radial neck correlation:* Posterior interosseous nerve run around neck of radius.
  - *Lister tubercle:*
    - Radius nailing entry point is just lateral to lister tubercle
    - EPL (extensor policis longus) tendon lies medial to lister tubercle.
  - *Mobile wad of Henery:*
    - Brachioradialis
    - Extensor carpi radialis longus (ECRL)
    - Extensor carpi radialis brevis (ECRB)
  - *Content of dorsal compartment of wrist:* (6 compartment) (Fig. 45.12)

I Abductor pollicis longus and extensor pollicis brevis.
II Extensor carpi radialis longus and extensor carpi radialis brevis.
III Extensor pollicis longus.
IV Extensor digitorum communis, extensor indicis proprius, posterior interosseous nerve and anterior interosseous artery.
V Extensor digiti minimi.
VI Extensor carpi ulnaris.

BONES OF WRIST AND HAND

- *Carpals, metacarpals and phalanges (Fig. 45.13)*:
  - *Carpal bones:* 8

Proximal carpal row:
- Scaphoid—boat-shaped bone
- Lunate—half moon-shaped bone
- Triquetral—pyramid-shaped bone
- Pisiform—pea-shaped (a sesamoid bone)

Distal carpal row:
- Trapezium—quadrangular bone
- Trapezoid—baby shoe shaped bone
- Capitate—largest carpal bone
- Hamate—wedge shaped bone

– *Metacarpals:* 5
– *Phalanx proximal:* 5
– *Middle:* 4
– *Distal:* 5

• *Attachments over wrist and hand bones:* (Fig. 45.14)

• *Ossification center:*
– Scaphoid—5 years
– Lunate—4 years
– Triquetral—3 years
– Pisiform—12 years
– Trapezium—5 years
– Trapezoid—5 years
– Capitate—1 year
– Hamate—1 year.

• *Muscles of hand:*
– *Thenar muscle:*
- Abductor pollicis brevis
- Flexor pollicis brevis
- Opponens pollicis
- Adductor pollicis.

– *Hypothenar muscle:*
- Abductor digiti minimi
- Flexor digiti minimi
- Opponens digiti minimi
- Palmars brevis.

– *Lumbricals:* 4 (Fig. 45.15A)
– *Palmar interossei (PI):* 4 (Fig. 45.15B)
– *Dorsal interrosei (DI):* 4 (Fig. 45.15C); 3rd metacarpal has no palmar interossei.

• *Points of orthopedic significance:*
– *Space of Poirier:*

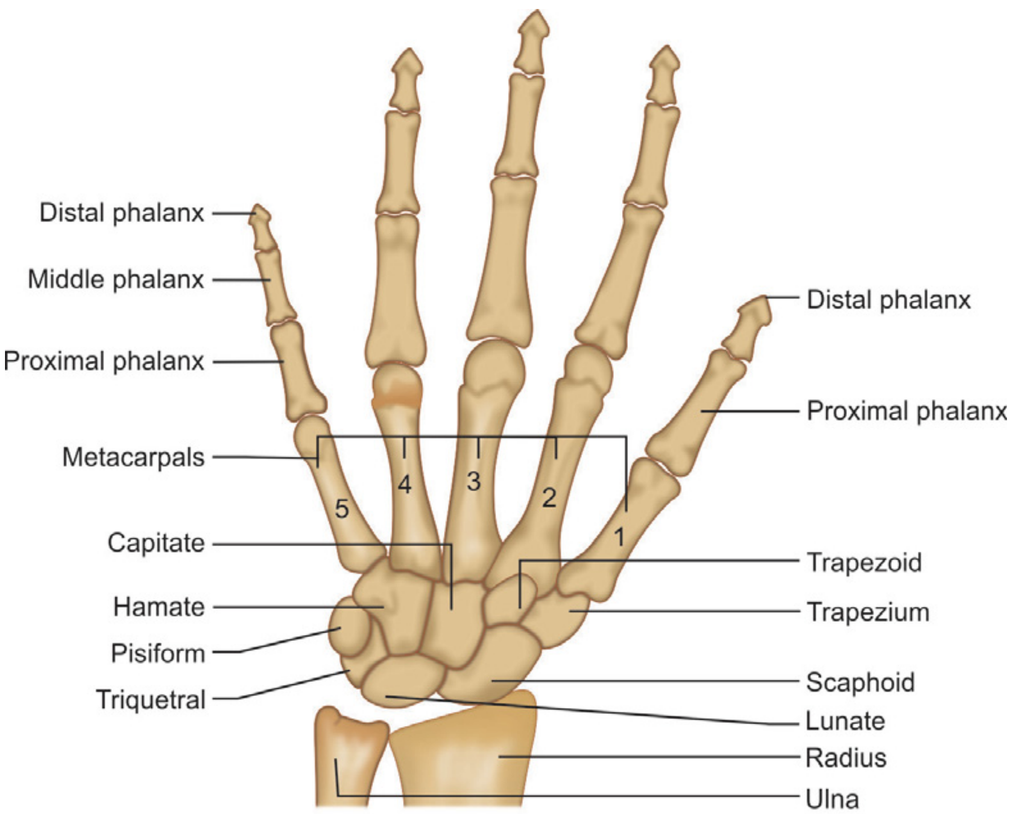


Fig. 45.13 Carpals, metacarpals and phalanges
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- It is interval between lunate and capitate bone.
- It has poor ligamentous support hence associated with perilunate dislocation.

– *Guyon's canal or ulnar tunnel:*
- It is piso-hamate canal of 4 cm length.
- It contains deep branch of ulnar nerve and ulnar artery.

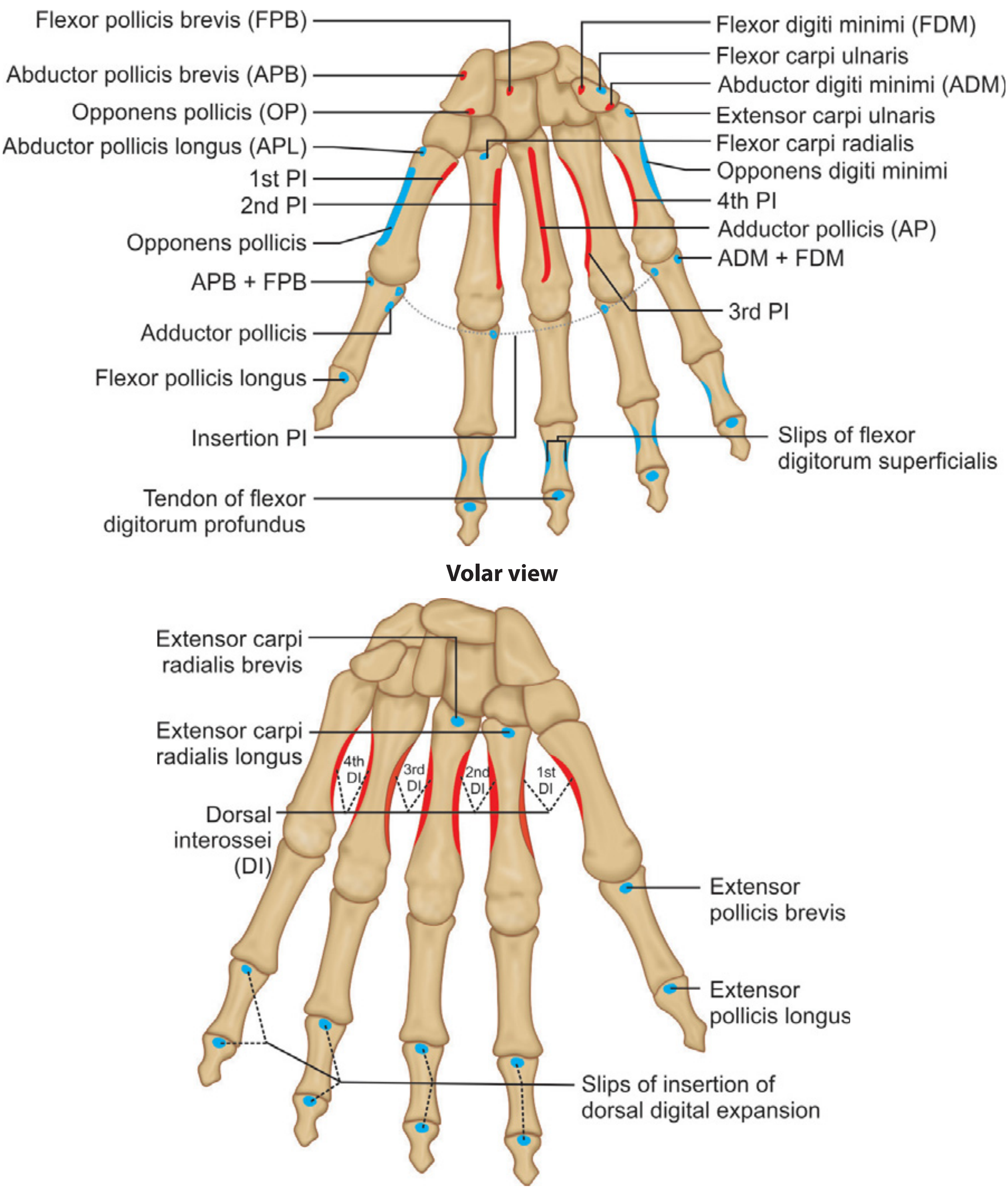


Fig. 45.14 Attachments over wrist and hand bones
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

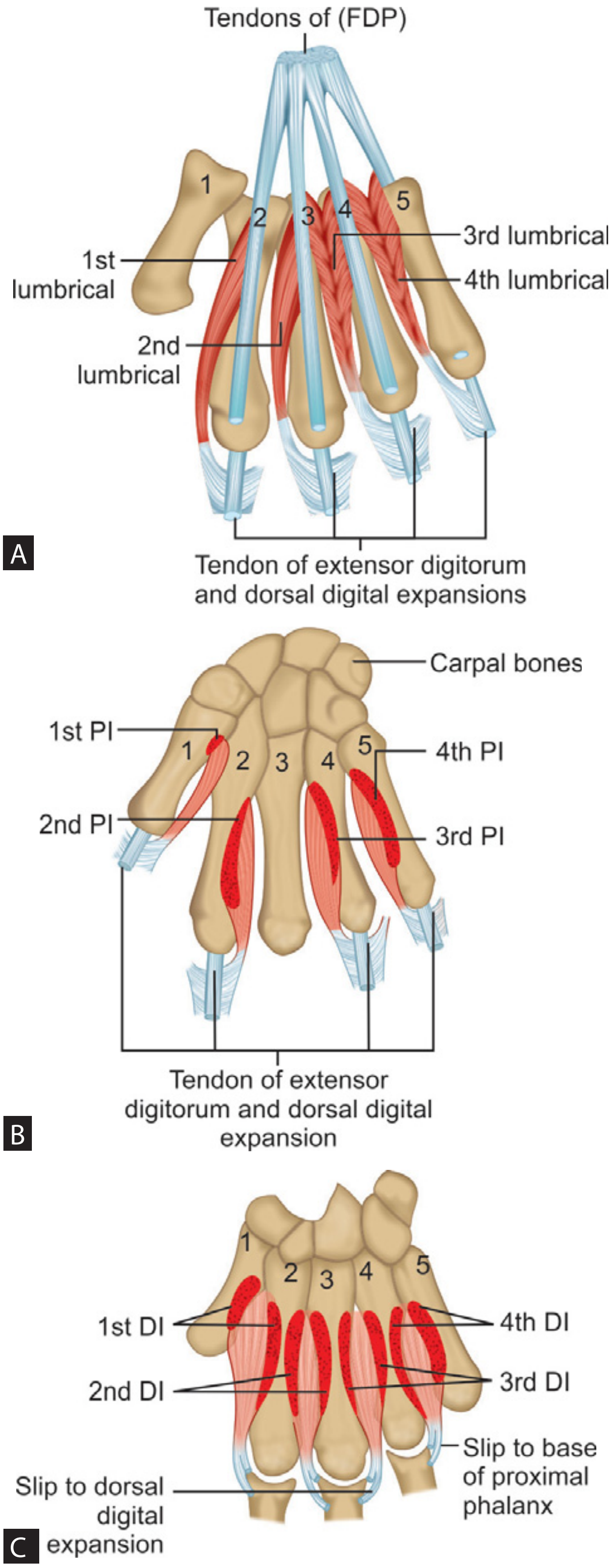
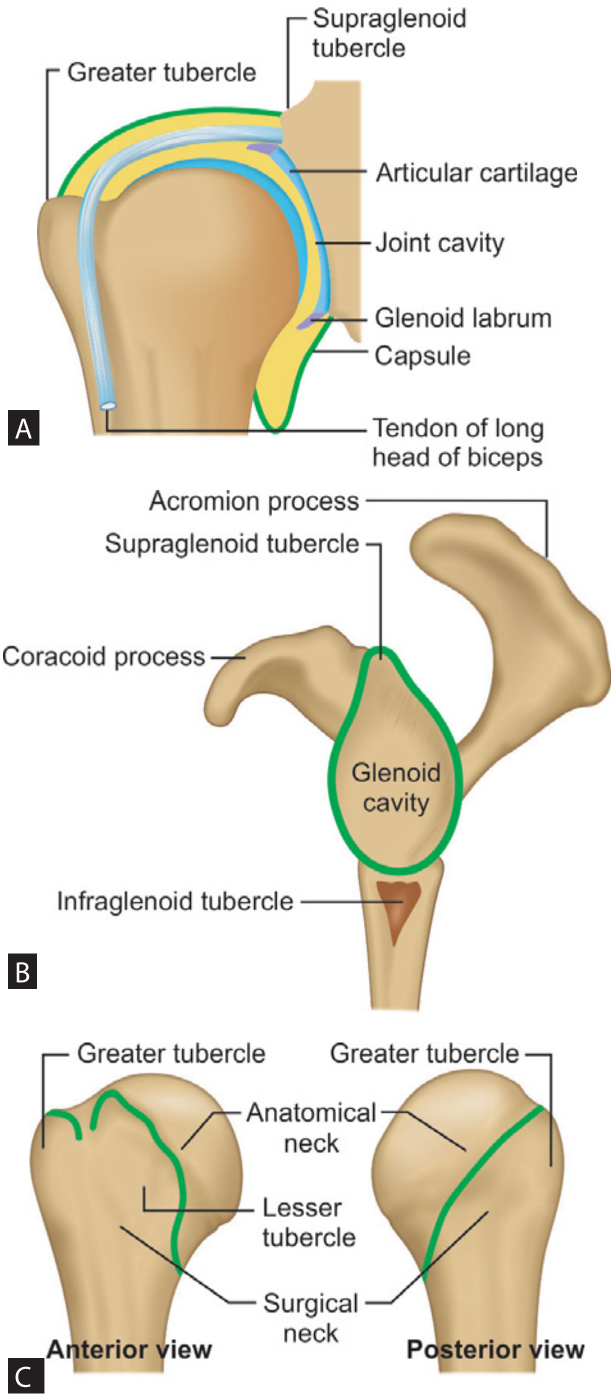


Fig. 45.15A to C Musules of the plam: (A) 4 lumbricals; (B) 4 palmar interossei (PI); (C) 4 dorsal interossei (DI) (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Blood supply of Scaphoid:*
  - 2/3rd of bone is covered by cartilage-intraosseus blood supply.
    - *Scaphoid branch of radial artery:*
      - Through dorsal ridge—80%, proximal 2/3rd of bone
      - Through volar tubrcle—20%, distal 1/3rd of bone.
    - A branch through scapholunte ligament
  - *Blood supply of proximal pole is precarious.*
    - In 67%—two or more vascular foramen proximal to waist.
    - In 20%—one vascular foramen proximal to waist.
    - In 13%—no vascular foramen proximal to waist.

SHOULDER JOINT

- *Joint type:* Ball and socket type
- *Joint capsule (Figs 45.16A to C)*:
  - *Capsule attachment:*
    - In scapula—around glenoid labrum
    - In humeral head—around anatomical neck of humerus except inferomedially where it extends up to surgical neck.
  - *Peculiarities of shoulder joint capsule:*
    - Superiorly there is a rent for tendon of long head of biceps
    - Anteriorly capsule is strengthen by glenohumeral ligament.
- *Ligaments around shoulder joint (Fig. 45.17)*:
  - Coracoacromial ligament
  - Coracoclavicular ligamenttrapezoid and conoid component
  - Coracohumeral ligament
  - Glenohumeral ligament
  - Transverse humeral ligament—over proximal part of bicipital groove.
- *Movement at shoulder and pectoral girdle:*
  - There is contribution in ratio of 2:1 by shoulder and scapula respectively during these movement.



Figs 45.16A to C Attachment of capsule around shoulder joint
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

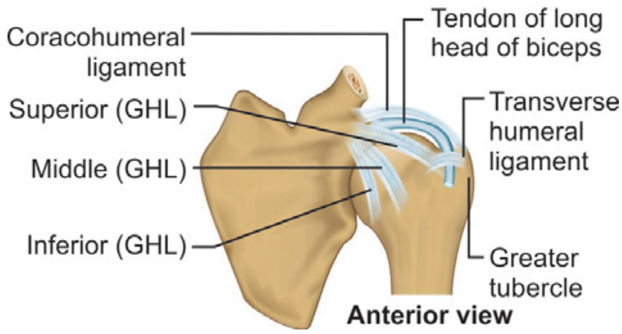


Fig. 45.17 Ligaments around shoulder joint
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- The axis of movement lie 15° anterior to true coronal plane of our body.

Movement at shoulder and pectoral girdle are as: (prime movers)
• *Flexion:* Anterior fibers of deltoid and pectoralis major
• *Extension:* Posterior fibers of deltoid and latissimus dorsi
• *Aduction:* Pectoralis major and latissimus dorsi
• *Abduction:* First 15° by supraspinatus, 15°–90° by deltoid and over 90° by trapezius and serratus anterior
• *Internal rotation:* Anterior deltoid, pectoralis major and subscapularis
• *External rotation:* Posterior fibers of deltoid, Infraspinatus and teres minor
• *Elevation:* Upper fiber of trapezius and levator scapulae
• *Depression:* Pectoralis minor and inferior fibers of serratus anterior
• *Protraction:* Serratus anterior and pectoralis minor
• *Retraction:* Rhomboids and middle fibers of trapezius.

- *Points of orthopedic significance:*
  - *Shoulder joint complex:* It contain four joints.

- Glenohumeral joint
- Acromioclavicular joint
- Sternoclvicular joint
- Scapula-thoracic association.

– *Shoulder restraints:*
  - *Dynamic restraint:* Long head of biceps and rotator cuff.
  - *Static restraint:*
    - *Bony:* Coracoacromial arch, glenoid cavity, and head of humerus.
    - *Soft tissue:* Glenoid labrum, coracohumeral ligaments, glenohumeral ligaments, capsule, and negative joint pressure.

– *Rotator cuff:*
  - It is formed by contribution of supraspinatus, infraspinatus, teres minor and subscapularis.
  - It increases the stability of shoulder joint.

– *Rotator interval:*
  - A gap between supraspinatus and subscapularis.
  - Contains coracohumeral and superior glenohumeral ligaments.
  - This gap can be used in reduction of posterior dislocation.

– ***Saha's*** *Zero position of shoulder:*
  - When shoulder is abducted to 165° and then 45° forwardly flexed, now there is no movement at head of humerus when forearm and hand are allowed to rotate (Saha's zero position).
  - When a dislocated shoulder is allowed to achieve this position passively; the dislocated shoulder reduces with a sound of click (Saha's method).

– ***Saha's*** *functional classification of shoulder movement:*

- *Prime movers:* Deltoid and clavicular head of pectoralis major
- *Steerer:* Supraspinatus, infraspinatus subscapularis
- *Depressor:* Latissimus dorsi, teres major, teres minor

ELBOW JOINT

- *Joint-type:* Humero-ulnar joint: hinge type.
- *Joint capsule (Figs 45.18A and B)*:
  – *Capsule attachment:*
    - In distal humerus—around margin of olecranon fossa, radial and coronoid fossa, just lateral to capitulum and medial to medial ridge of trochlea.
    - Ulna—around margin of trochlear notch.

  – Annular ligament of superior radio-ulnar joint communicate with elbow joint capsule.
- *Ligaments around elbow joint (Fig. 45.19A)*:
  – *Lateral collateral ligament (Fig. 45.19B):*

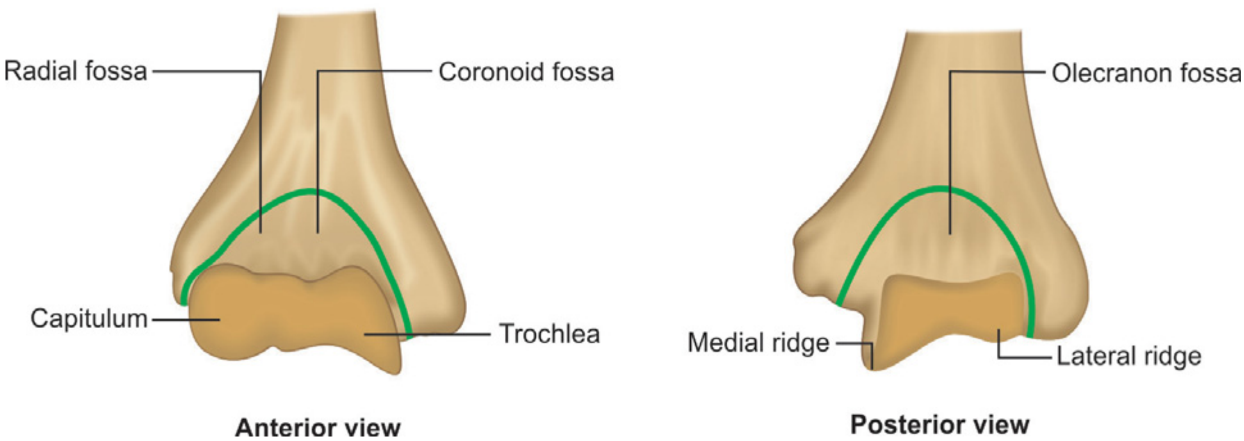


Fig. 45.18A Attachment of capsule around elbow (disital humerus)
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

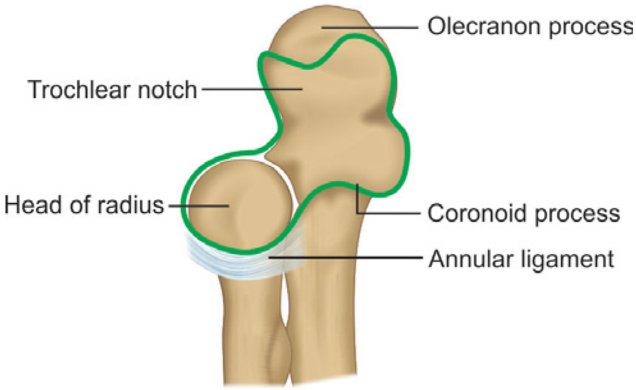
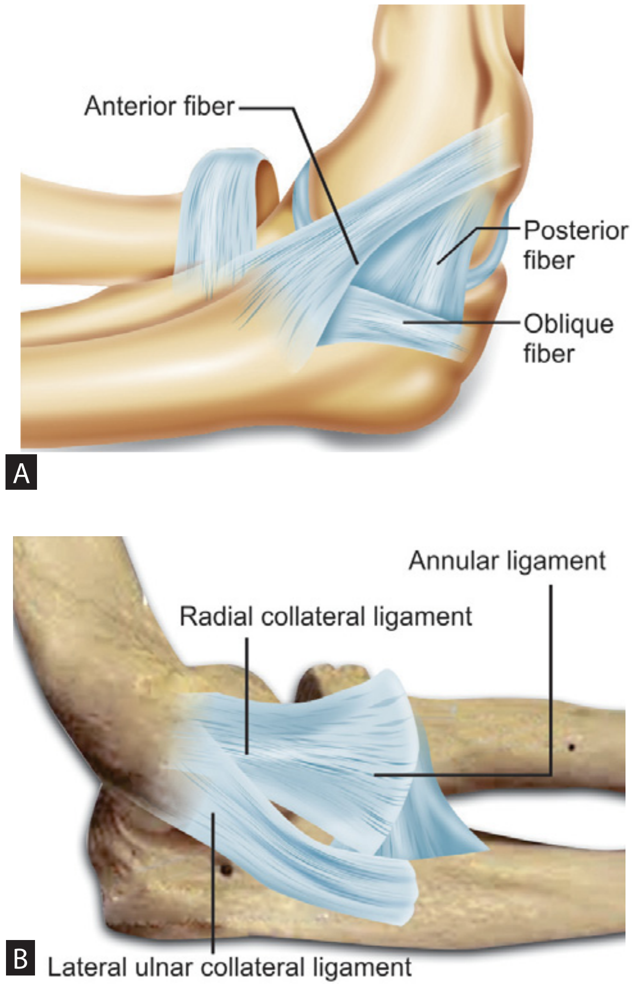


Fig. 45.18B Attachment of capsule around elbow (proximal radius and ulna)
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)



Figs 45.19A and B (A) Lateral collateral ligament complex; (B) Medial or ulnar collateral ligament complex

- Radial collateral ligament
- Annular ligament
- Lateral ulnar collateral
- *Medial or ulnar collateral ligament:*
  - Anterior fiber—cord like
  - Posterior fibers—fan like
  - Oblique fibers.

- *Movement around elbow:*
  - Only flexion and extension can take place at elbow
  - Supination and pronation takes place at superior and inferior radio-ulnar joint.

> - *Flexion:*
>   - When forearm supinated—brachialis and biceps brachii
>   - When forearm in mid-prone—brachioradialis
>   - When forearm pronated—brachialis
> - Extension—triceps, and anconeus
> - *Supination:*
>   - When elbow extended—supinator
>   - When elbow is flexed—biceps (in first 40°)
> - Pronation—pronator teres and pronator quadratus

- *Points of orthopedic significance:*
  - *Elbow joint complex:* It has three articulations
    - Humero-ulnar joint
    - Radio-capitellar joint
    - Superior radio-ulnar joint.
  - *Elbow restraints:*
    - Dynamic restraints—anconeus, triceps, brachialis.
    - *Static restraints:*
      - *Bony:* Radial head, capitellum, trochlea, coronoid process, olecranon tip coronoid process.
      - *Soft tissue:* Medial collateral ligament, lateral collateral ligament, common flexors and common extensors origin.
  - *Anconeus triangle:* The lateral epicondyle, tip of olecranon and radial head; these three bony points makes a triangle when elbow is flexed to 90°; triangle is called anconeus triangle.

- *Carrying angle of elbow:* Angle between long axis of arm and forearm when elbow is fully extended and supinated.
  - Carrying angle of elbow disappears when forearm is pronated or elbow is flexed.
  - Carrying angle in male—10° and female—15°–20°.
  - It gives pelvic clearance in female.
  - *Factors responsible for carrying angle:*
    - Obliquity of the superior surface of coronoid process of ulna.
    - Medial ridge of trochlea lies distal to lateral ridge.
- ***Heuter's** line and triangle:* The medial epicondyle, lateral epicondyle and tip of olecranon lie in a straight line when elbow is fully extended but these 3 bony points make a triangle when elbow is fully flexed; these are called Heuter's line and Heuter's triangle respectively.

WRIST JOINT

- *Joint type:* Radio-carpal joint—ellipsoid type
- *Joint capsule (Fig. 45.20)*:
  - *Capsule attachment:*

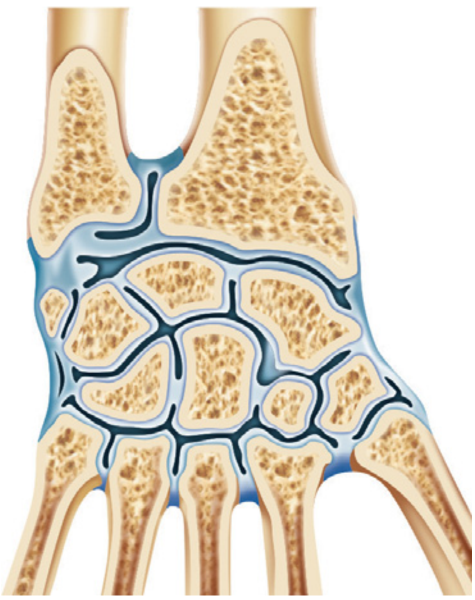


Fig. 45.20 Section of wrist joint with capsular extension

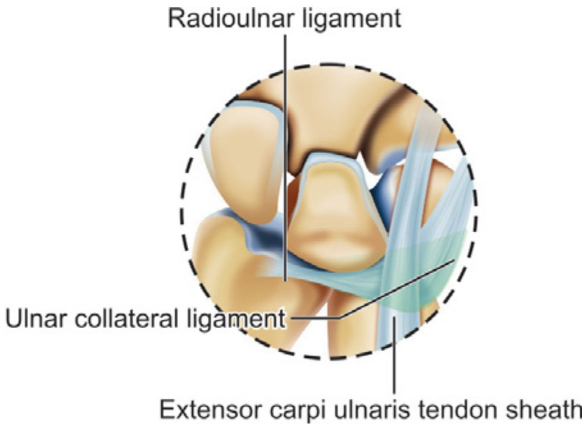


Fig. 45.21A Dorsal view of TFCC
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

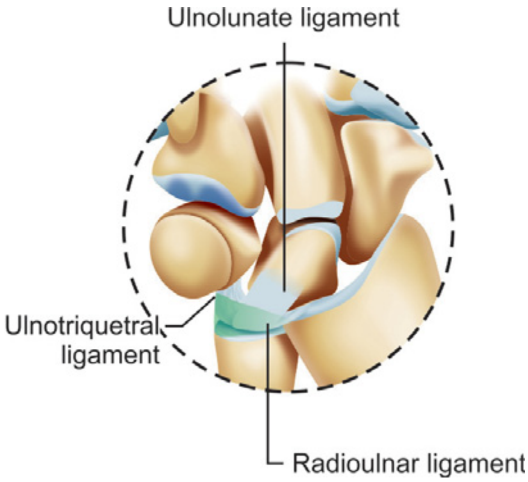


Fig. 45.21B Volar view of TFCC
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

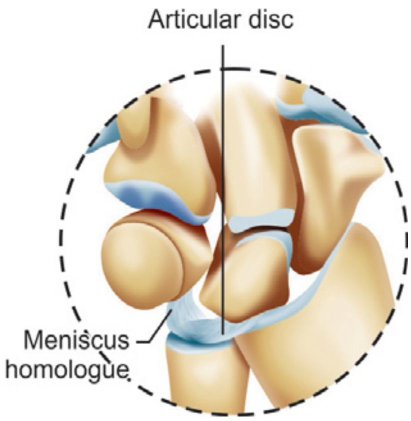


Fig. 45.21C Articular disc and meniscus homologue
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

    - *In radius and ulna:* Margin of lower end of radius and ulna.
    - *In carpal bone:* Along proximal row of carpal bones (scaphoid, lunate and triquetral).
- The inferior radio-ulnar joint also communicate with wrist joint capsule.
- *Ligaments around wrist joint and TFCC complex (Figs 45.21A to C):*
  - *Important ligament around wrist joint as follows:*
    - Radio-carpal ligament
    - Ulno-carpal ligament
    - Inter-carpal ligament
    - Radial-collateral ligament
    - Ulno-collateral ligament.
  - *Triangular fibro-cartilage complex (TFCC):*
    - *Dorsal TFCC:* Dorsal radio-ulnar ligament, ulnar collateral ligament, tendon seath of extensor carpi ulnaris, articular disc, meniscus homologue.
    - *Volar TFCC:* Volar radio-ulnar ligament, ulnolunate ligament, ulnotriquetral ligament, articular disc, meniscus homologue.
- *Movement around wrist:*
  - Wrist flexion and abduction chiefly takes place at mid-carpal joint.
  - Wrist extension and adduction mainly takes place at radio-carpal joint.

> - *Wrist-flexion:* Flexor carpi radialis, flexor carpi ulnaris
> - *Wrist-extension:* Extensor carpi radialis longus and brevis
> - *Wrist-abduction:* Flexor carpi radialis, extensor carpi radialis longus and brevis, abductor pollicis longus, extensor pollicis brevis
> - *Wrist-adduction:* Flexor carpi ulnaris and extensor carpi ulnaris
> - *Wrist-circumduction:* Combination movement

  - *Movement at 1st carpometacarpal joint (prime movers).*

> - *Flexion:* Flexor pollicis brevis
> - *Extension:* Abductor pollicis longus, extensor pollicis brevis
> - *Abduction:* Abductor pollicis brevis, abductor pollicis longus
> - *Adduction:* Adductor pollicis
> - *Opposition:* Opponens pollicis

- *Points of orthopedic significance:*
  - *Wrist joint complex have:*
    - Radiocarpal and mid-carpal joint
    - Inferior radio-ulnar joint.
  - *Triangular fibrocartilage (articular disc):*
    - Triangular in shape with an apex and a base
    - Its periphery is thicker than center
    - *Attachment:* Apex is attached to the base of ulnar styloid process and base is attached with inferior border of ulnar notch of radius.

CHAPTER

46

Bones and Joints of Lower Limb

PELVIC BONE

- *Morphology of pelvic bone (Figs 46.1A and B):*
  - *Border and surfaces*
    - ◆ *Ilium:*
      - Anterior, posterior and medial (iliac crest to iliopubic eminence) border.
      - Surfaces—gluteal surface, iliac fossa and sacropelvic surface.
    - ◆ *Pubic:* Body and superior ramus:
      - Body—anterior, posterior (pelvic) and medial (symphyseal joint) surface.
      - Superior ramus—anterior, superior, and inferior border and pectineal, pelvic and obturator surface.
    - ◆ *Ischium:*

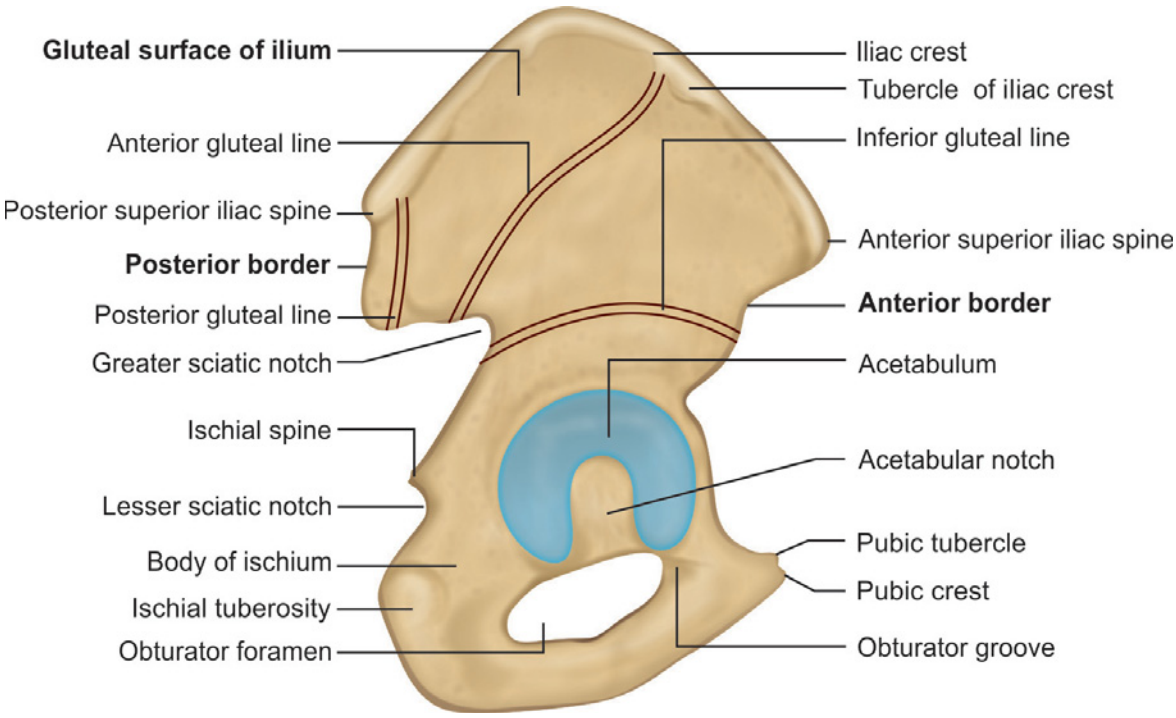
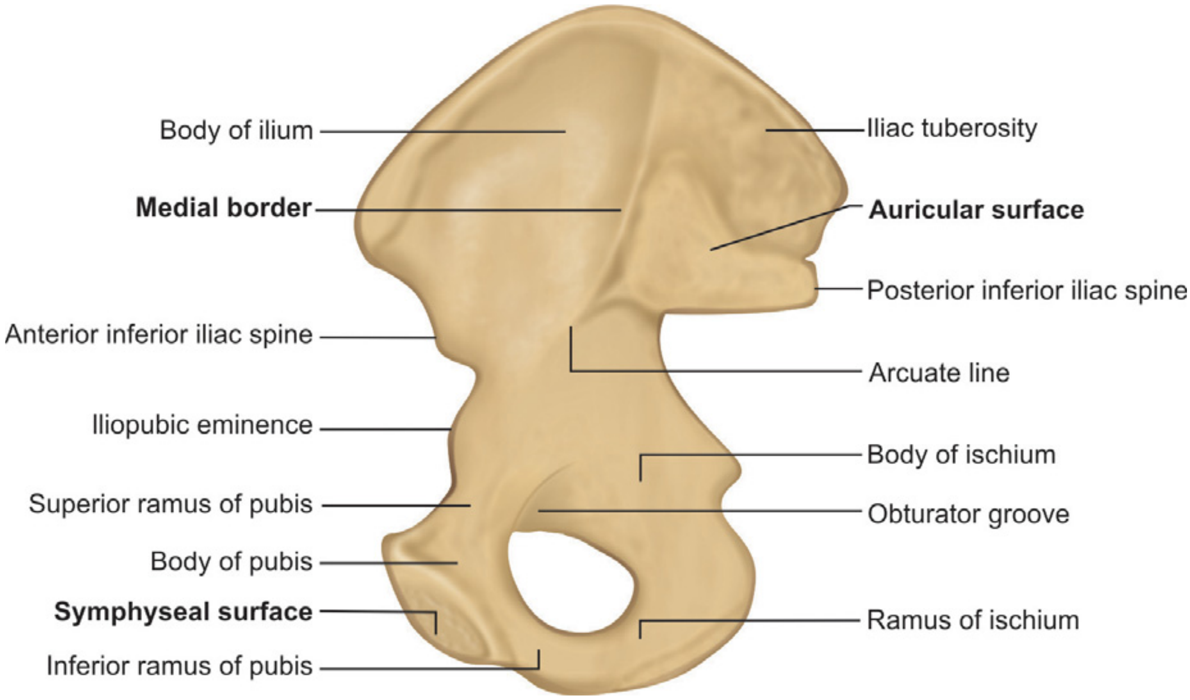


Fig. 46.1A Morphology of pelvic bone
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)



Inner view

Fig. 46.1B Morphology of pelvic bone
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

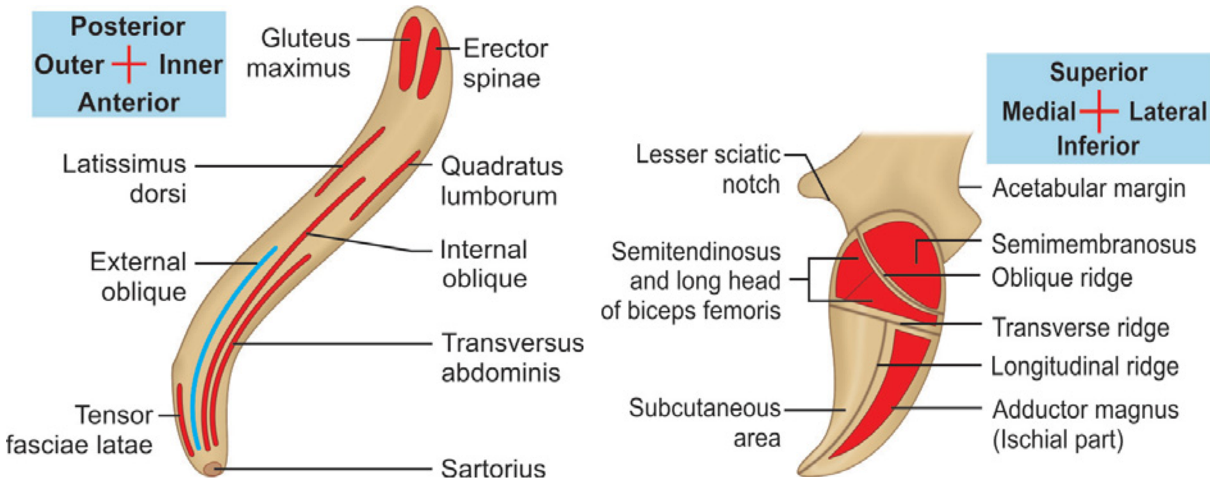
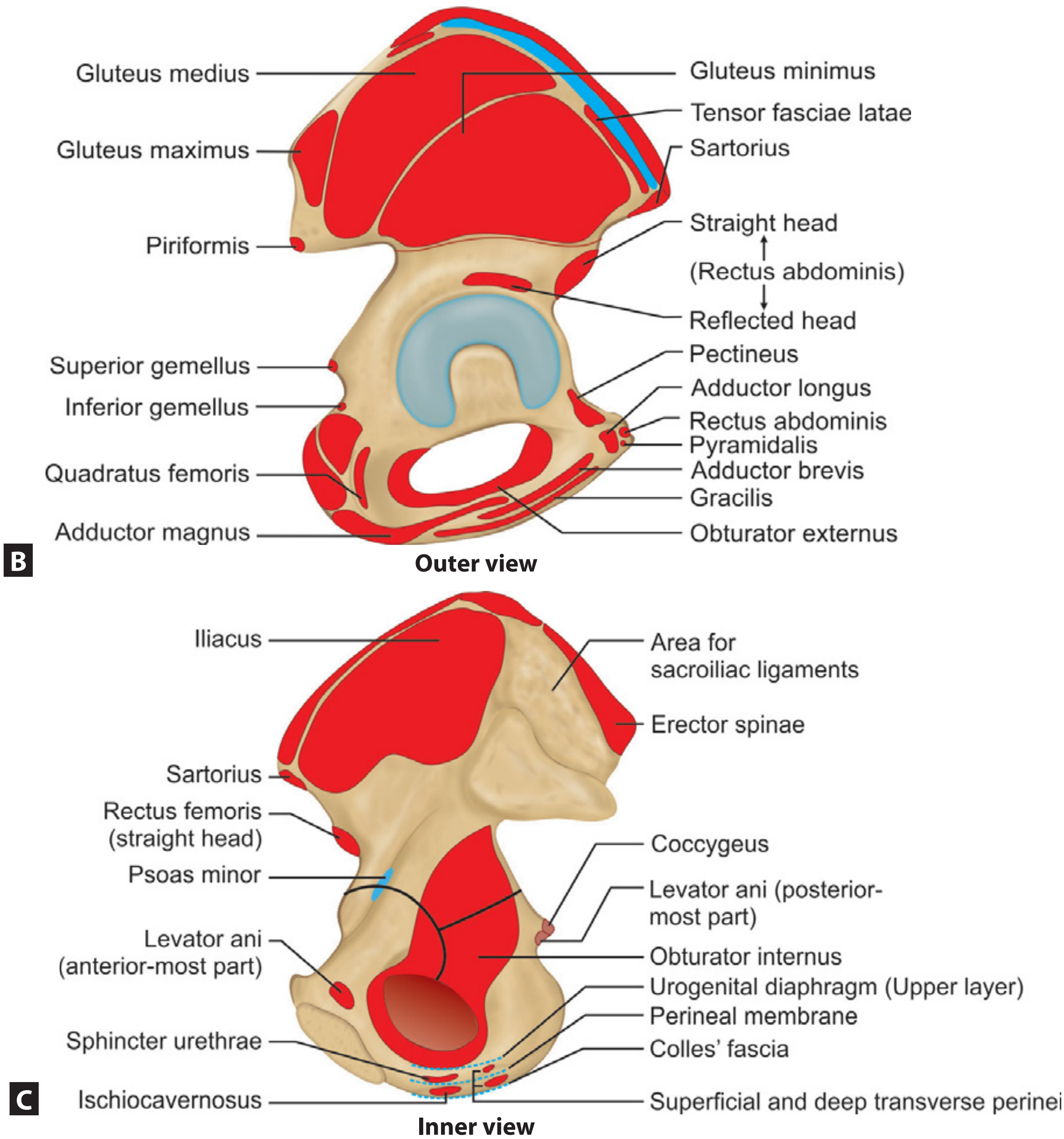


Fig. 46.2A Attachments over pelvic bone (Iliac crest and Ischial tuberosity)
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- Border—anterior, posterior and lateral border.
- Surfaces—dorsal and lateral (femoral) surface.

- *Attachments over pelvic bone (Figs 46.2A to C):*
- *Gluteal muscles:*
  - *Larger muscle:*
    - Gluteus maximus
    - Gluteus medius
    - Gluteus minimus.
  - *Small muscle:*
    - Piriformis
    - Quadratus femoris
    - Gemelli superior
    - Gemelli inferior
    - Obturator internus
    - Obturator externus
    - Tensor fascia lata.



Figs 46.2B and C Attachments over pelvic bone
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Ossification center:*
  - *Primary:* 3 (iliium-1, ischium-1, pubic-1)
  - *Secondary:* 5
  - Fusion of physis
- *Points of orthopedic significance:*
  - *Structures passing through greater sciatic foramen:* Above piriformis
    - Superior gluteal nerve
    - Superior gluteal vessel.
  - *Structures passing through greater sciatic foramen:* Below piriformis
    - Inferior gluteal nerve
    - Inferior gluteal vessel
    - Sciatic nerve
    - Posterior cutaneous nerve of thigh
    - Nerve to quadratus femoris
    - Pudendal nerve
    - Internal pudendal vessels
    - Nerve to obturator internus.
  - *Structures who enter the lesser sciatic foramen:* (PINT)
    - Pudendal nerve

- Internal pudendal vessels
- Nerve to obturator internus
- Tendon of obturator internus.

FEMUR

- *Morphology of femur:* Border and surfaces of shaft (middle 1/3rd) (Fig. 46.3)
  - *Border:* Medial, lateral and posterior borders.
  - *Surfaces:* Anterior, medial and lateral surfaces.

Comparison between medial and lateral condyle		
Points	*Medial condyle*	*Lateral condyle*
Anteroposterior diameter	More	Lesser
Width	More	Lesser
Prominence of trochlear ridge	Less	More
Surface	Medial surface convex	Lateral surface flat

- *Attachments over femur (Fig. 46.4)*
- *Ossification center:*
  - *Primary:* 1
  - *Secondary:* 3 upper end and 1 lower end
  - *Time of appearance of upper end ossification center:*
    - Head of femur—6 month
    - Greater trochanter—4 years
    - Lesser trochanter—12 years.
  - *Fusion of physis:*
    - Upper end—18 years
    - Lower end—20 years.
- *Compartment of thigh:* Intermuscular septum (Fig. 46.5)
  - *Anterior compartment:*
    - Sartorius
    - Quadriceps femoris—rectus femoris, vastus lateralis, vastus medialis, vastus intermedius
  - *Posterior compartment:*
    - Semitendinosus
    - Semimembranosus
    - Biceps femoris
    - Hamstring part of adductor magnus.

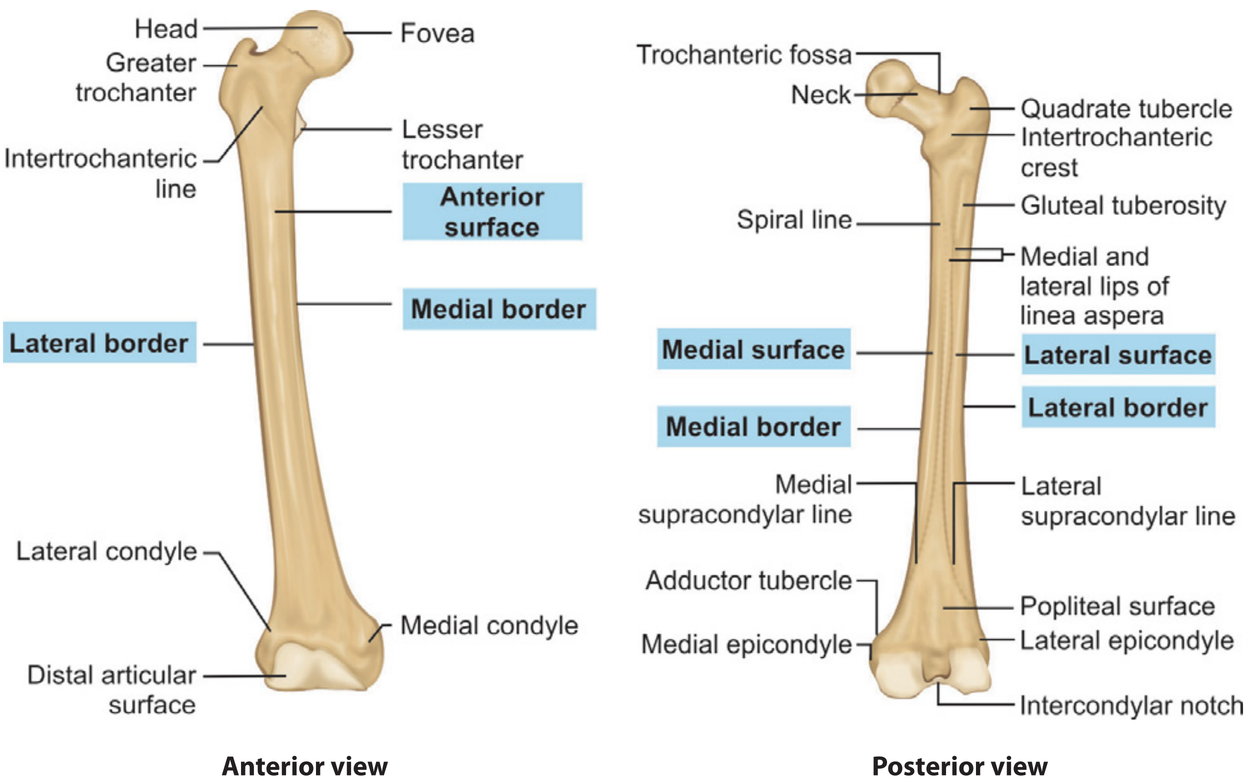


Fig. 46.3 Morphology of femur
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

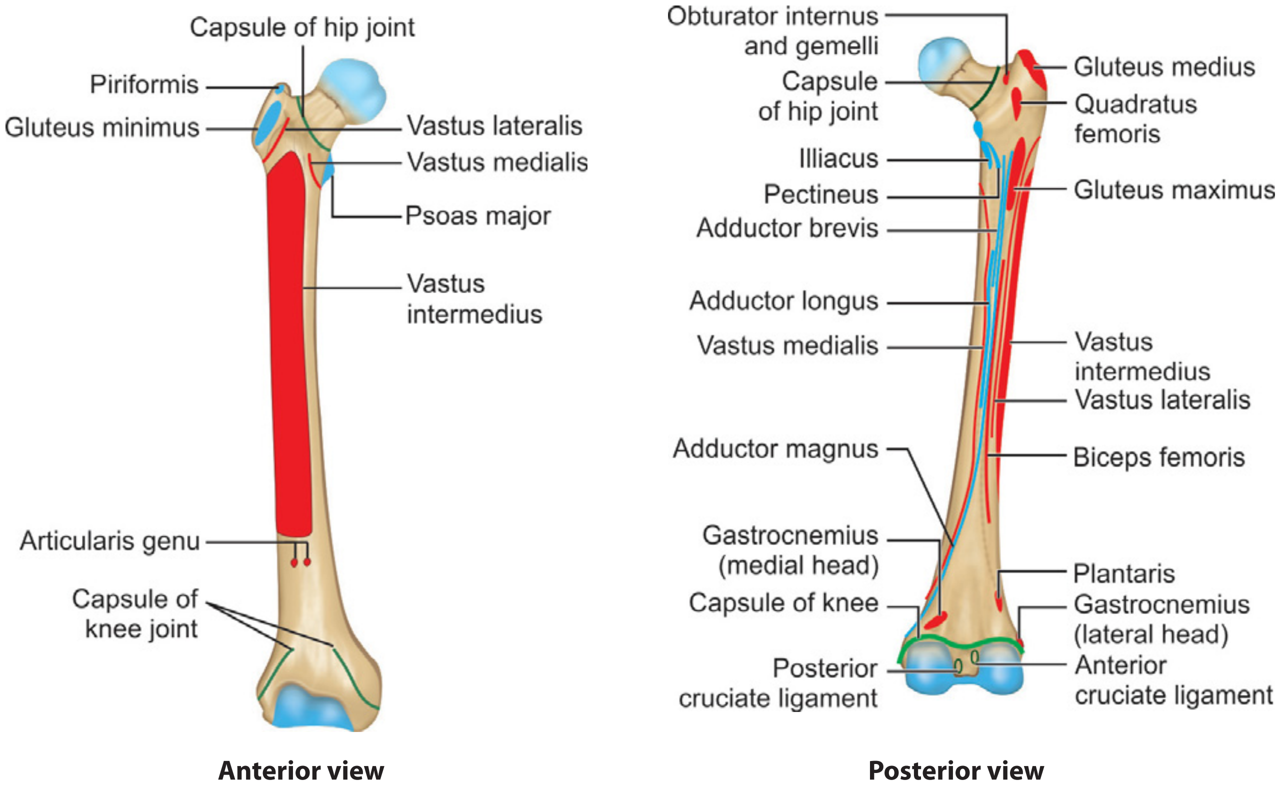


Fig. 46.4 Attachments over femur
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

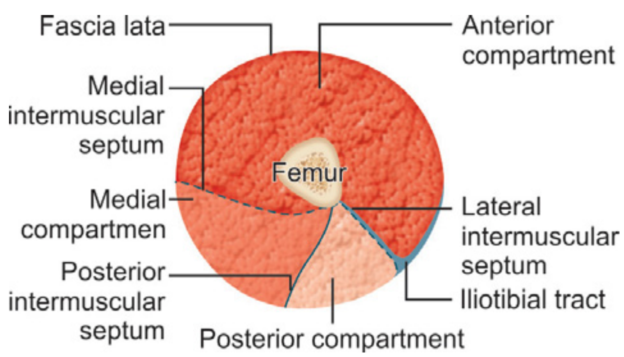


Fig. 46.5 Compartment of thigh
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Medial compartment:*
  - Adductor longus
  - Adductor brevis
  - Adductor magnus—only adductor part
  - Gracilis
  - Pectineus.

Order of attachment of muscles around lateral surface, linea aspera and medial surface of shaft femur (lateral to medial)

Contd...

Contd...

I—vastus intermedius (origin) ↓ Left—vastus lateralis (origin) ↓ Bike—short head of biceps (origin) ↓ Mela—adductor magnus (insertion) ↓ Before—adductor brevis (insertion-above) ↓ Lawn—adductor longus (insertion-below) ↓ Meal—vastus medialis (origin)

- *Points of orthopedic significance:*
  - *Angle of anteversion of femoral neck:*
    - At birth—40°
    - At age of 16 years settle at 15°.
  - Femoral neck shaft angle—average 125°
  - *Illiotibial band (Fig. 46.6)*:
    - Its two components are gluteus maximus and tensor fascia lata or femoris.

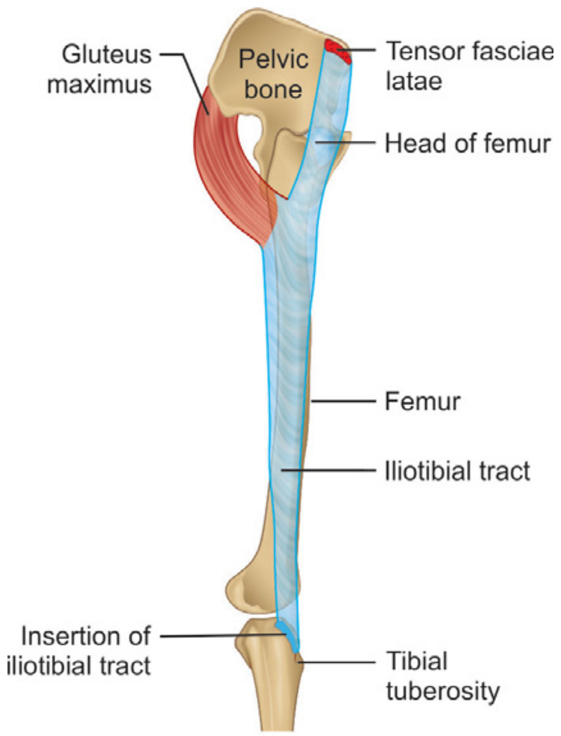


Fig. 46.6 Illiotibial band
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

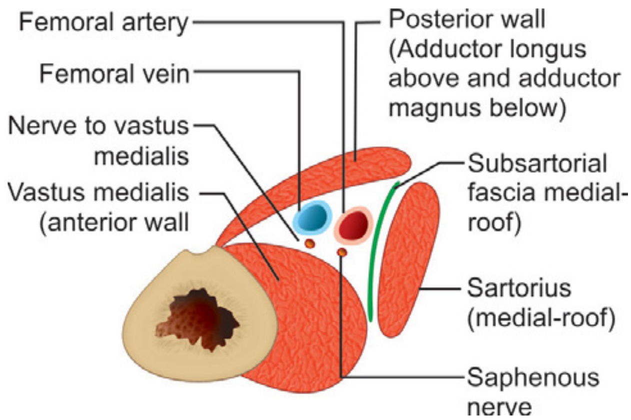


Fig. 46.7 Adductor or **Hunter's** canal
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

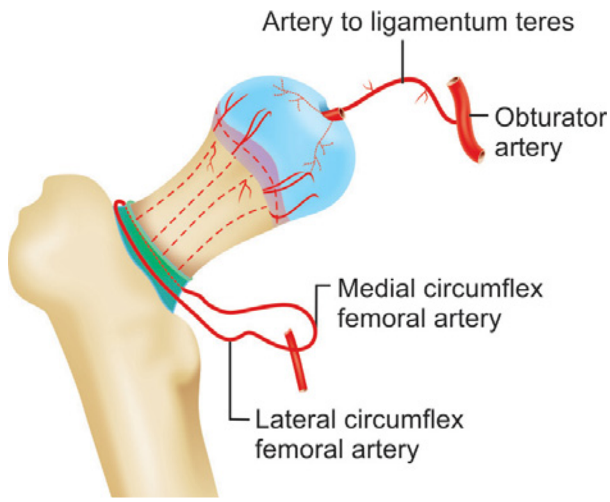


Fig. 46.8 Blood supply of head of femur

- It is knee stabilizer in extension and partial flexion.

– *Adductor or **Hunter's** canal (Fig. 46.7):*
  - *Boundaries:*
    - Anterior—vastus medialis,
    - Posterior (floor)—adductor longus above and adductor magnus below
    - Medial (roof)—a fibrous structure that attaches anterior and posterior wall; and Sartorius over it.
  - *Content:* Femoral artery, femoral vein, saphenous nerve.

– *Blood supply of head of femur (Fig. 46.8):*
  - *Extracapsular arterial ring located at the base of neck:* Ring of **crook**

Femoral artery
↓
profunda femoris branch
↓
medial circumflex femoral from poster side (main supply) and lateral circumflex femoral from anterior side

Contd...

Contd...

↓
formation of extracapsular arterial ring

- *Subsynovial intracapsular ring:* Ring of **Chung**

Extracapsular arterial ring
↓
metaphyseal arteries like anterior, posterior, medial and lateral (main) ascending cervical branches of neck (retinacula of **Weitbretcht**)
↓
sub-synovial intracapsular ring
↓
lateral epiphyseal branches (**Trueta**) and some metaphyseal branches

Contd...

Contd...

- *Artery to ligamentum teres:*

Obturator artery
↓
foveal branch
↓
artery to ligamentum teres
↓
possible anastomosis with above artery

- *Blood supply of head of femur according to age:*
  - *0–4 months:* Lateral epiphyseal and metaphyseal supply present.
  - *4 months–4 years:* Lateral epiphyseal branches present but metaphyseal supply diminishes due growth plate appearance.
  - *4–8 years:* Only supply by lateral epiphyseal vessel—**vulnerable head**.
  - *8 years to adolescent:* Along with lateral vessels, supply from artery to ligamentum teres establishes.
  - *Adult:* Physis fused and all three (lateral epiphyseal, metaphyseal and artery to ligamentum teres) blood supply present.

PATELLA

- *Morphology of patella (Figs 46.9A and B):*
  - Border and surfaces
    - Border—superior, medial and lateral borders
    - Surfaces—anterior and posterior surfaces.
- *Muscle attachments on patella (Fig. 46.10)*:
- *Development and ossification center of patella:*
  - A sesamoid bone
  - Developed under tendon of quadriceps
  - Several ossification center.
- *Extensor apparatus around patella:*
  - Quadriceps femoris muscle
  - Ligamentum patellae
  - Medial retinaculum
  - Lateral retinaculum.
- *Points of orthopedic significance:*
  - Largest sesamoid bone
  - Improves the lever action of quadriceps.

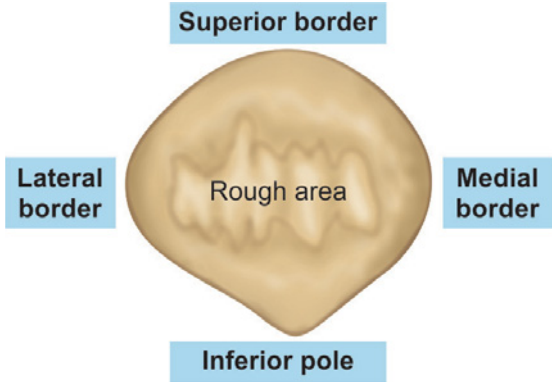


Fig. 46.9A Anterior surface of patella (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

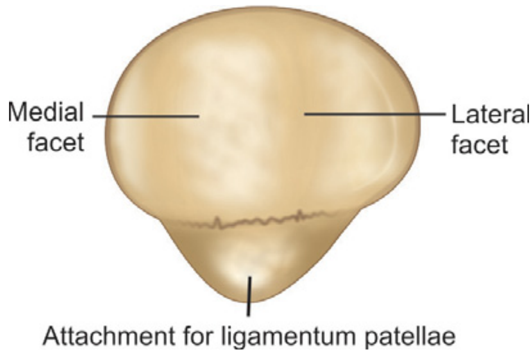


Fig. 46.9B Posterior surface of patella (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

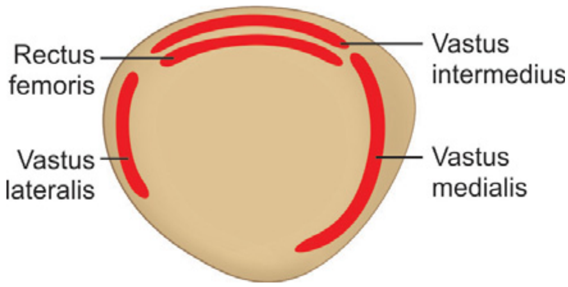
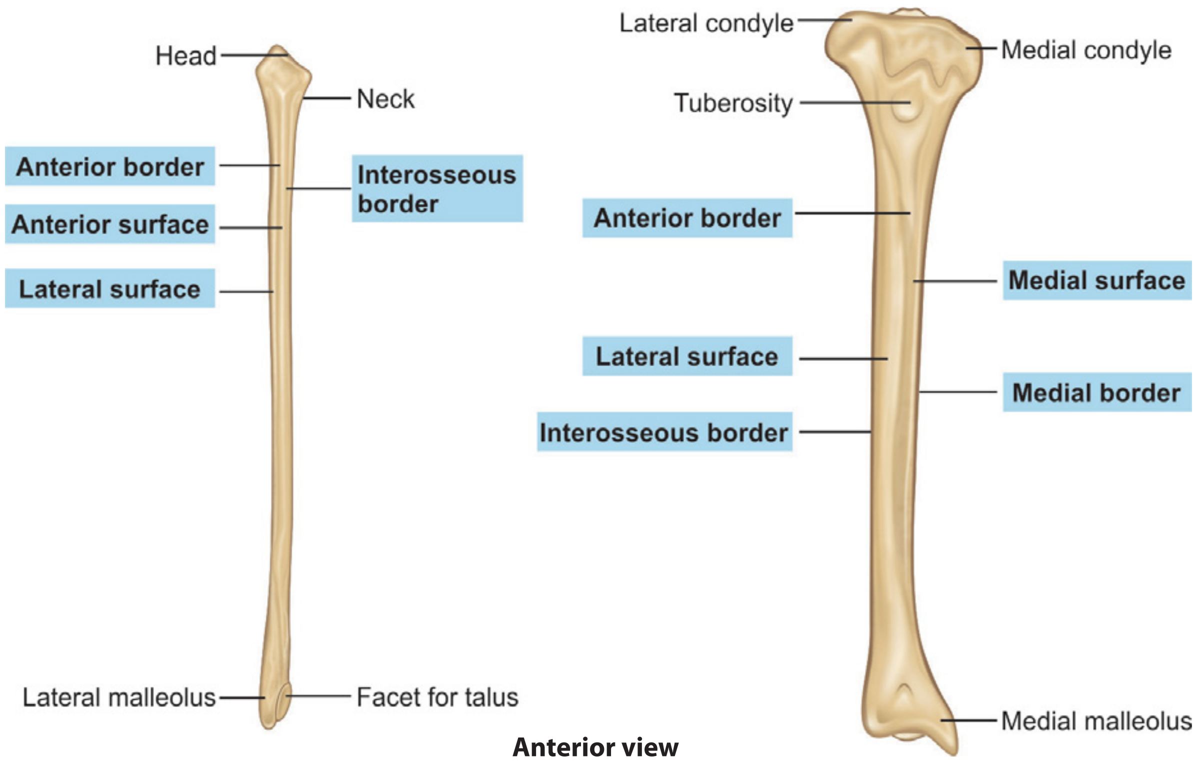


Fig. 46.10 Muscle attachments on patella (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

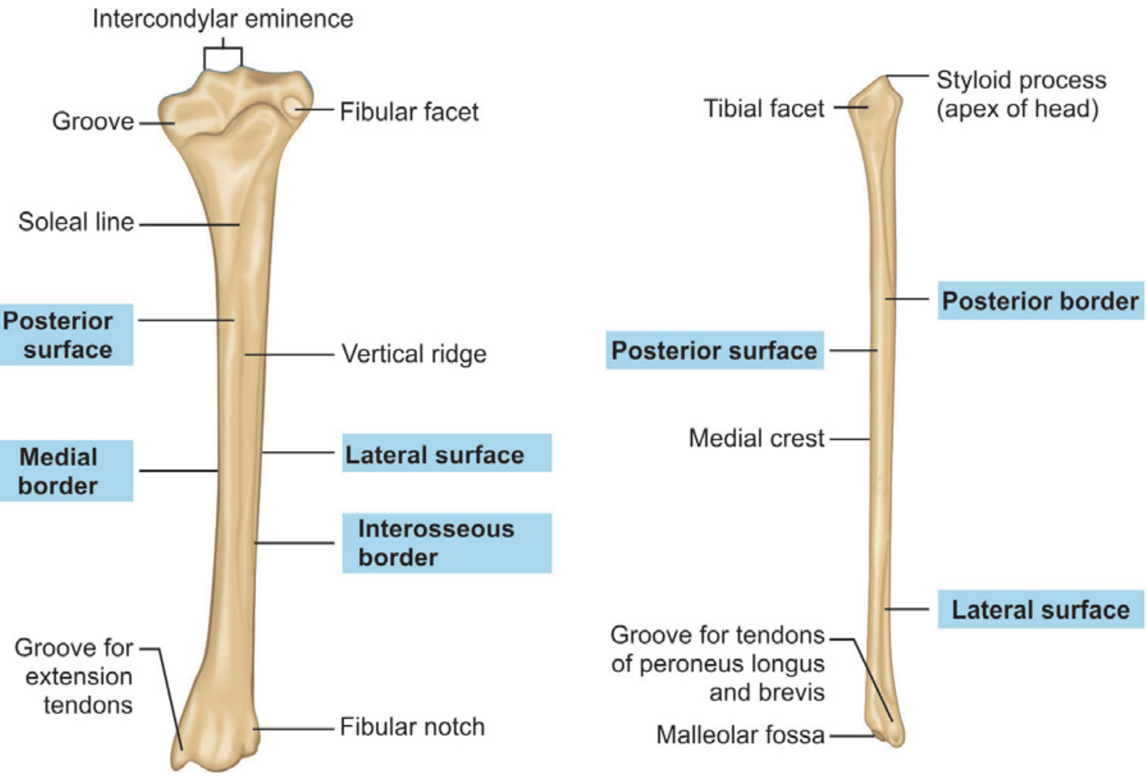
TIBIA AND FIBULA

- *Morphology of tibia and fibula:* (Figs 46.11A to C)
  - Border and surfaces of shaft tibia
    - Border—anterior, medial and inter-osseous or lateral
    - Surface—medial, lateral and posterior (divided medial and lateral half by vertical ridge)



Anterior view

Fig. 46.11A Morphologys of tibia
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)



Posterior view

Fig. 46.11B Morphology of fibula
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Border and surfaces of shaft fibula:*
  - Border—anterior, posterior and interosseous or medial.
  - Surface—medial, lateral and posterior (divided medial and lateral half by vertical ridge).
- *Attachments over tibia and fibula (Figs 46.12A and B):*

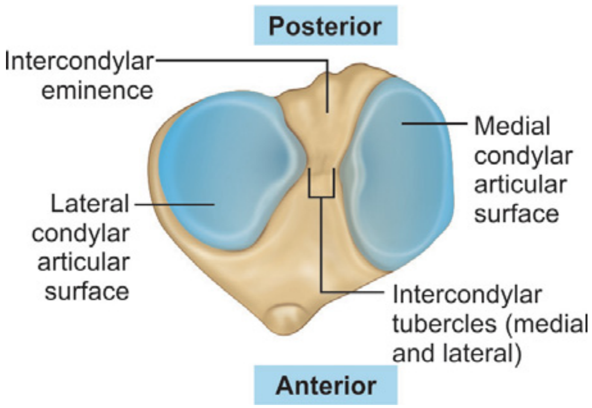


Fig. 46.11C Tibial condyle
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Ossification center:*
  - *Primary:* 1 (tibia) and 1 (fibula)
  - *Secondary:* 2 (tibia) and 2 (fibula), one in upper end and one in lower end.
  - *Fusion of physis:*
    - *Tibia:* 16–18 years at upper end and 15–17 years at lower end.
    - *Fibula:* 18 years at upper end and 16 years at lower end.
- *Compartment of leg:* Interosseous membrane and intermuscular septum (Fig. 46.13)
  - *Anterior compartment:* (4 muscles)
    1. Tibialis anterior
    2. Extensor digitorum longus
    3. Extensor hallucis longus
    4. Peroneus tertius.
  - *Lateral compartment:* (2 muscles)
    1. Peroneus longus
    2. Peroneus brevis
  - *Posterior compartment:* (3 superficial muscle)
    1. Gastrocnemius
    2. Soleus
    3. Plantaris.

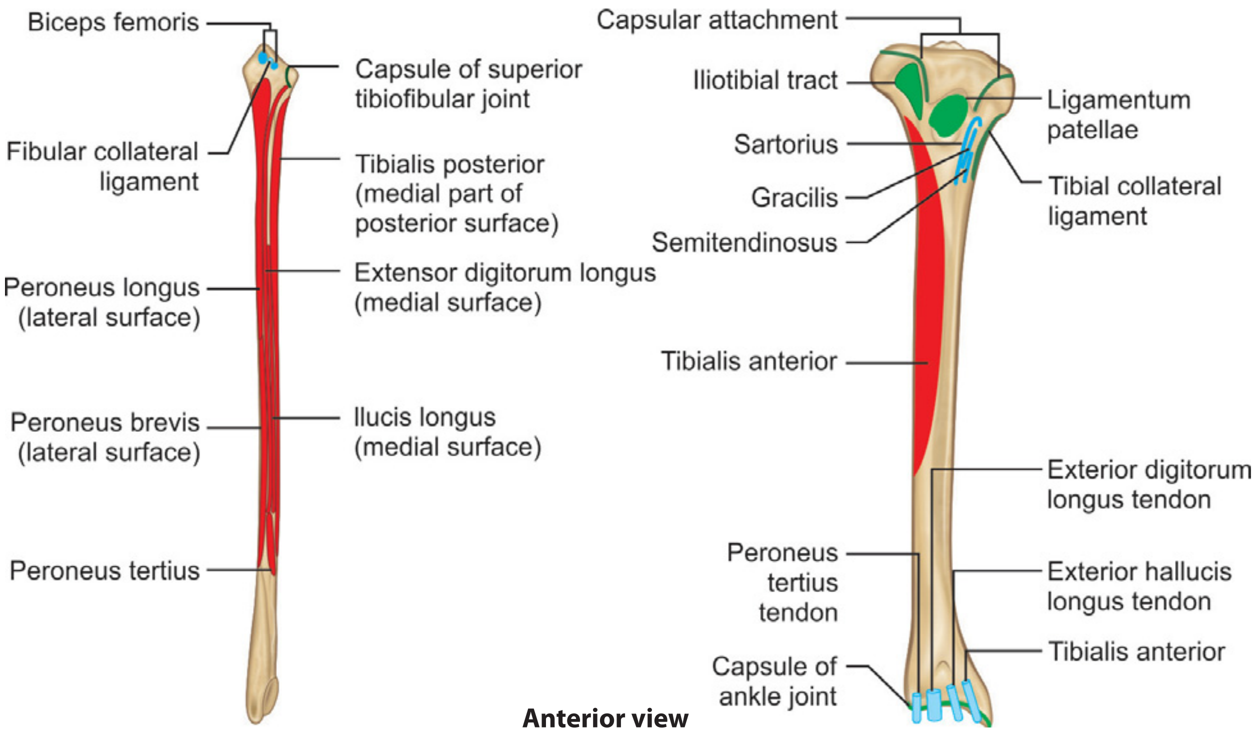


Fig. 46.12A Attachments over tibia
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

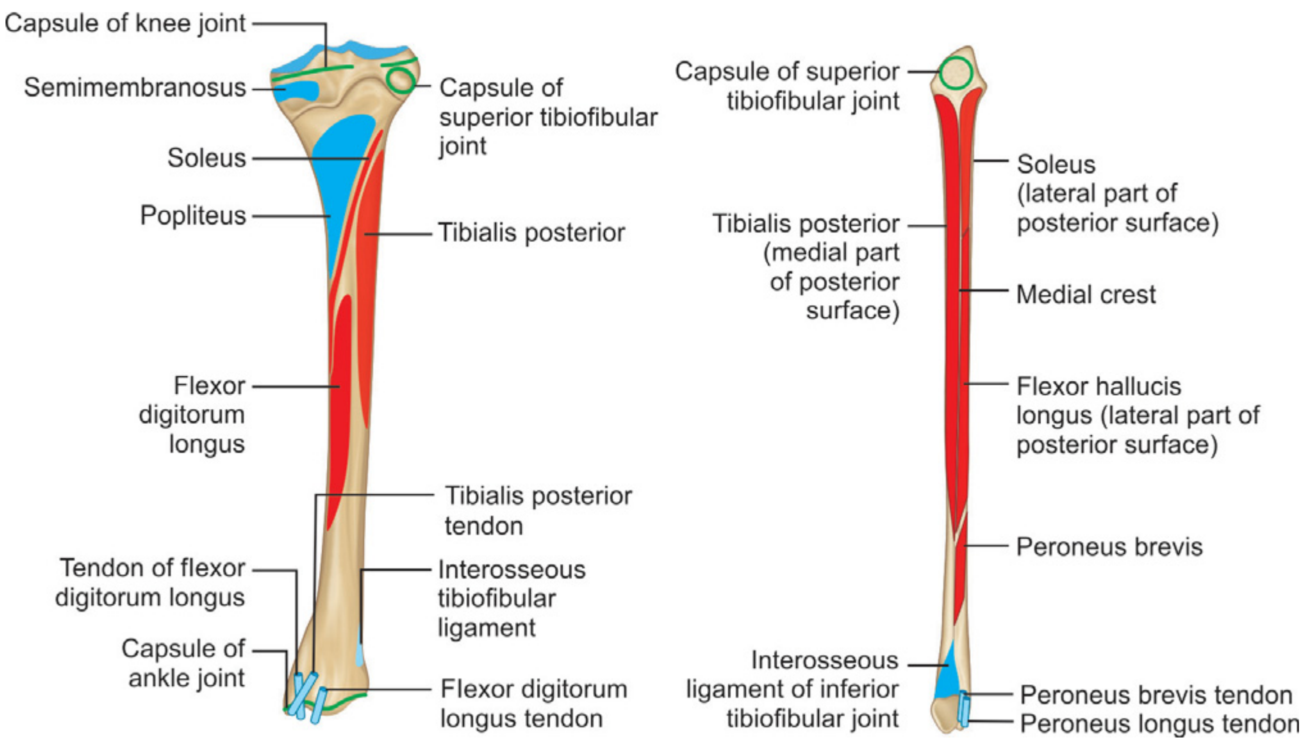


Fig. 46.12B Attachments over fibula
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

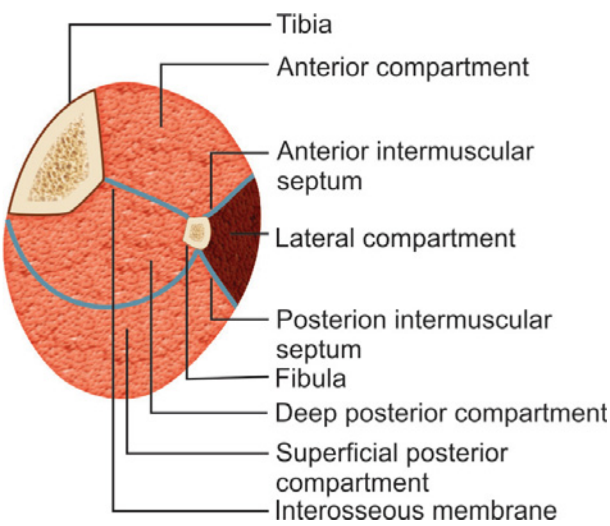


Fig. 46.13 Compartment of leg

- *Posterior compartment:* (4 deep muscles)
  1. Popliteus
  2. Tibialis posterior
  3. Flexor digitorum longus
  4. Flexor hallucis longus.
- *Points of orthopedic significance:*
  - *Guy ropes:*
    - It is formed by three muscle tendons originating from all three parts of pelvic bone (ilium, ischium, pubis) that holds the pelvis like rope of tent.
    - They represent the all three compartment of thigh.
    - They represent their separate nerve supply.
    - The muscles are as sartorius, gracillis, semitendinosus.
  - *Anserine bursae:* There is a bursae around insertion of tendons of guy ropes called anserine bursae.

BONES OF ANKLE AND FOOT

- *Tarsals, metatarsals and phalanges (Fig. 46.14)*:
  - *Tarsals bone:* 7
    Hind foot:
    - Calcaneus—anterior process, sustentaculum tali, tuberosity, medial process, body with three facet as anterior, middle and posterior.

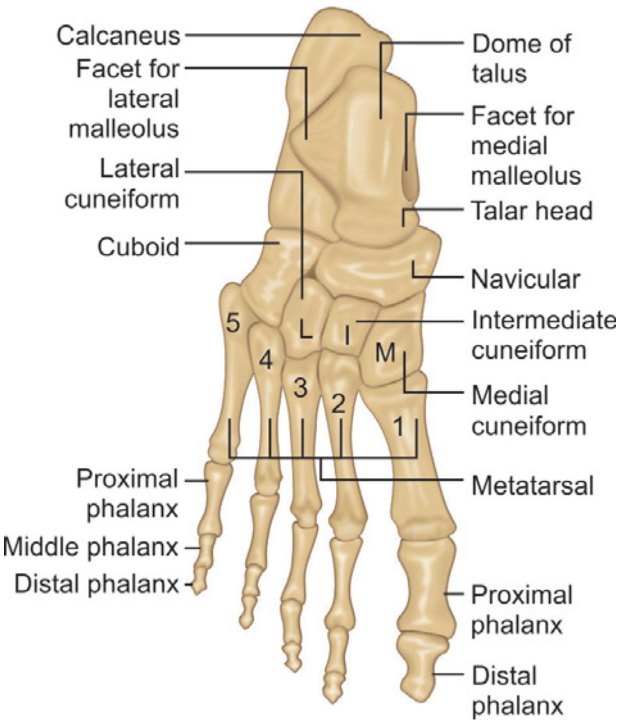


Fig. 46.14 Tarsals, metatarsals and phalanges (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- Talus—head, neck, body, lateral process, and posterior process.

Mid foot:

- Navicular
- Cuboid
- Medial cuneiform
- Intermediate cuneiform
- Lateral cuneiform.

– *Metatarsals:* 5
– *Phalanx:* Proximal 5, middle: 4, distal: 5

- *Muscle attachments on ankle and foot bone:* (Fig. 46.15).
- *Ossification center:*
  – The ossification center of talus and cuboid appear in intrauterine life (IUL).
    - Calcaneus—primary: 3rd month of IUL + secondary: 6–8 years, fusion 14–16 years
    - Talus—6th month of IUL
    - Navicular—3rd year
    - Cuboid—9th of IUL
    - Medial cuneiform—2nd year.

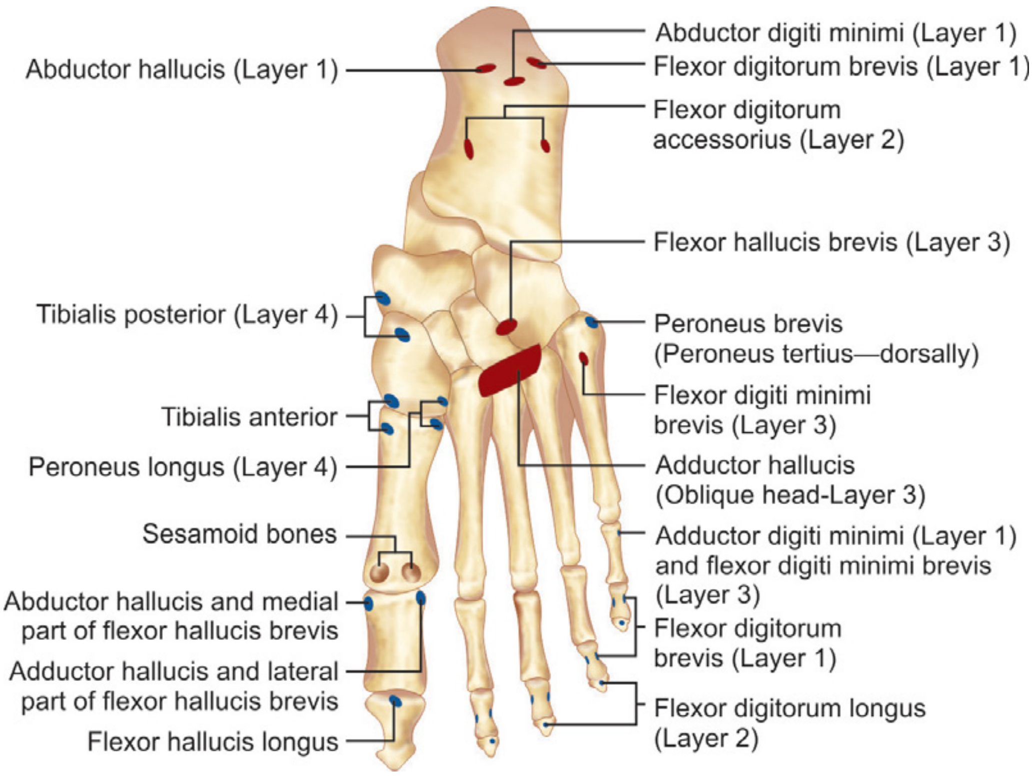


Fig. 46.15 Attachments over ankle and foot bone (Plantar view) (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- Intermediate cuneiform—3rd year
- Lateral cuneiform—1st year.
- *Muscles of foot:*
  - *Muscles on dorsum of foot (Fig. 46.16):*
    - Extensor hallucis brevis
    - Extensor digitorum brevis.
  - *Muscles in sole of foot:* From superficial to deep (Figs 46.17A to C)

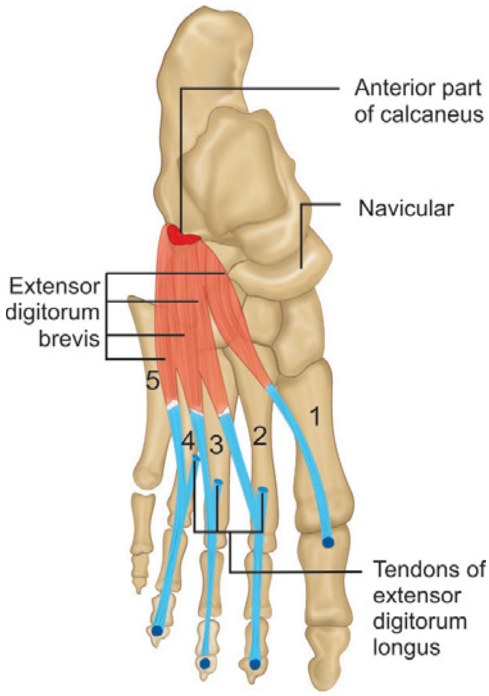


Fig. 46.16 Muscles on dorsum of foot (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

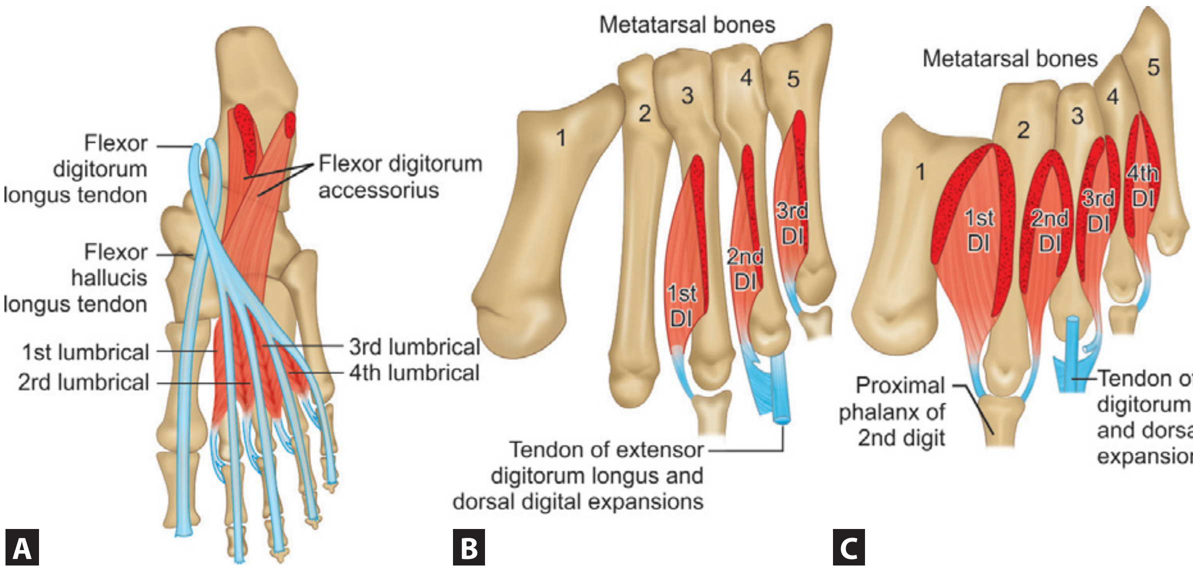
Layer-1
- Abductor hallucis
- Flexor digitorum bervis
- Abductor digiti minimi.

Layer-2
- Flexor digitorum longus
- Flexor digitorum accessories
- Lumbricals-4
- Flexor hallucis longus.

Layer-3
- Flexor hallucis brevis
- Adductor hallucis
- Flexor digiti minimi brevis.

Layer-4
- Interossei (Dorsal-4 and plantar-3)
- Tibialis posterior
- Peroneus longus

- *Points of orthopedic significance:*
  - *Tarsal tunnel:* A fibro-osseous canal behind medial malleoli.
  - Arches of foot
    - *Function:*
      - Distribution of body weight on sole, toes and heel.
      - Spring action helps in walking and running.
      - Shock absorber action helps in jumping.
      - Concavity of arch protect soft tissue of sole against pressure.



Figs 46.17A to C Muscles in sole of foot: (A) Lumbricals; (B) Dorsal interossei; (C) Plantar interossei (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

Components of arches of foot				
	Medial longitudinal arch	*Lateral longitudinal arch*	*Anterior transverse arch*	*Posterior transverse arch (incomplete arch)*
Ends:				
Anterior	Head of 1, 2, 3, metatarsal	Head of 4, 5 metatarsals	Head of 1st metatarsal	Maximum part of tarsus and metatarsus
Posterior	Medial tubercle of calcaneum	Lateral tubercle of calcaneus	Head of 5th metatarsal	
Summit	Superior articular surface of body of talus	Superior surface of calcaneum at subtalar joint level		
Pillar				
Anterior	Talus, navicular, all 3 cuneiform and medial three metatarsals	Cuboid, 4–5 metatarsal		
Posterior	Medial part of calcaneus	Lateral half of calcaneum		
Joint	Talo-calcaneal navicular joint	Calcaneocuboid joint		

- ◆ *Classification of foot arches:*
  - Longitudinal arch—medial and lateral.
  - Transverse arch—anterior and posterior.
- ◆ *Components of arches:*
- *Factor affecting stability of arches:*
  - *Bony factor:* Wedge-shaped cuneiform contribute to shape of posterior transverse arch.
  - *Intersegmental tie:*
    - ◆ Spring ligament in medial longitudinal arch
    - ◆ Long and short plantar ligament in lateral longitudinal arch
    - ◆ Interosseous muscle in transverse arches.
  - *Tie beam:*
    - ◆ Plantar aponeurosis and 1st layer of sole muscle for longitudinal arch.
    - ◆ Adductor haullicis muscle in transverse arches.
  - *Sling:*
    - ◆ Tibialis posterior, flexor haullicis longus, flexor digitorum longus act in medial longitudinal arch
    - ◆ Peroneus longus and brevis act in lateral longitudinal arch
    - ◆ Slips of tibialis posterior and peroneus longus acts in transverse arches.
- *Blood supply of talus:*
  - 60% of talus is covered by cartilage-intraosseous supply.
  - All three major artery of leg give supplies to talus as anterior tibial, posterior tibial and peroneal artery.
    - ◆ *Head and neck of talus:* Anterior tibial artery—dorsalis pedis artery—artery to sinus tarsi; enter from lateral side.
    - ◆ *Body of talus:* Posterior tibial artery—artery to tarsal canal (major supply)—deltoid branch (medial 1/4th of talus) anterior tibial artery—dorsalis pedis artery—artery to sinus tarsi: supplies lateral 1/8 to 1/4 of talus.
    - ◆ *Posterior tubercle:* Supplied by posterior tibial and peroneal artery.

HIP JOINT

- *Joint type:* Ball and socket type
- *Joint capsule (Fig. 46.18):*
  - *Capsule attachment:*
    - ◆ In acetabulum—along margin of acetabular labrum

- In proximal femur—along intertrochanteric line anteriorly and medial to intertrochanteric crest posteriorly.
  - The capsular coverage of anterior part of femur neck is more than that of posterior part.
- *Ligaments around hip joint (Fig. 46.19):*
  - Illeofemoral ligament (**Bigelow's** ligament)—anterior ligament, 'Y' shaped
  - Pubofemoral ligament—anterior ligament, triangular shape
  - Ischiofemoral ligament—posterior ligament
  - Ligamentum teres—intra-articular ligament
  - *Transverse ligament—bridges the acetabular notch:* A guide for acetabular reaming during THR.

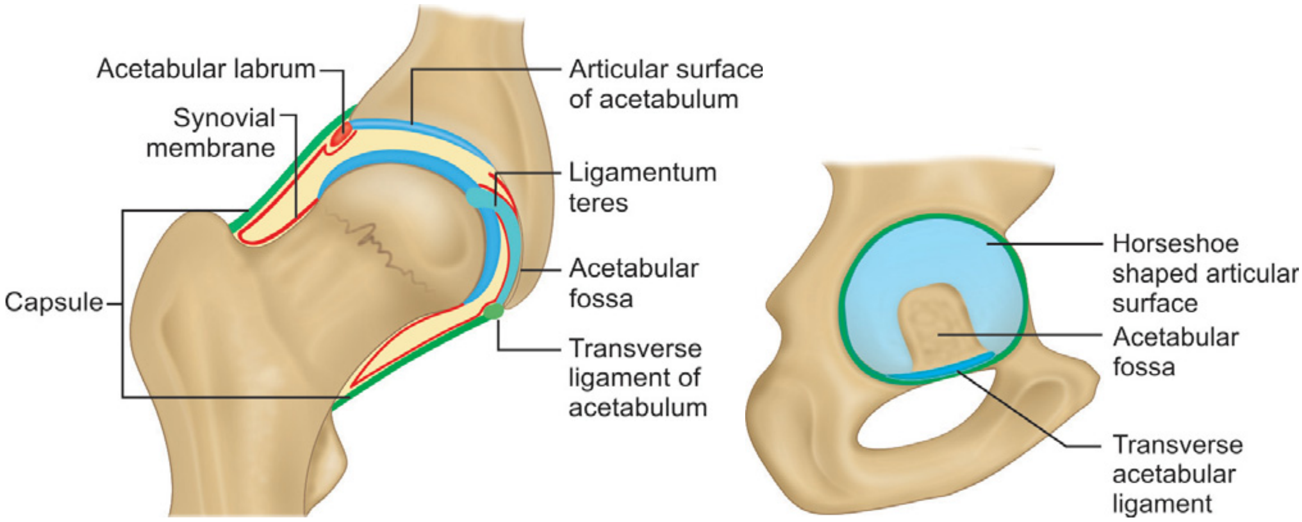


Fig. 46.18 Hip joint showing capsuler attachment
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

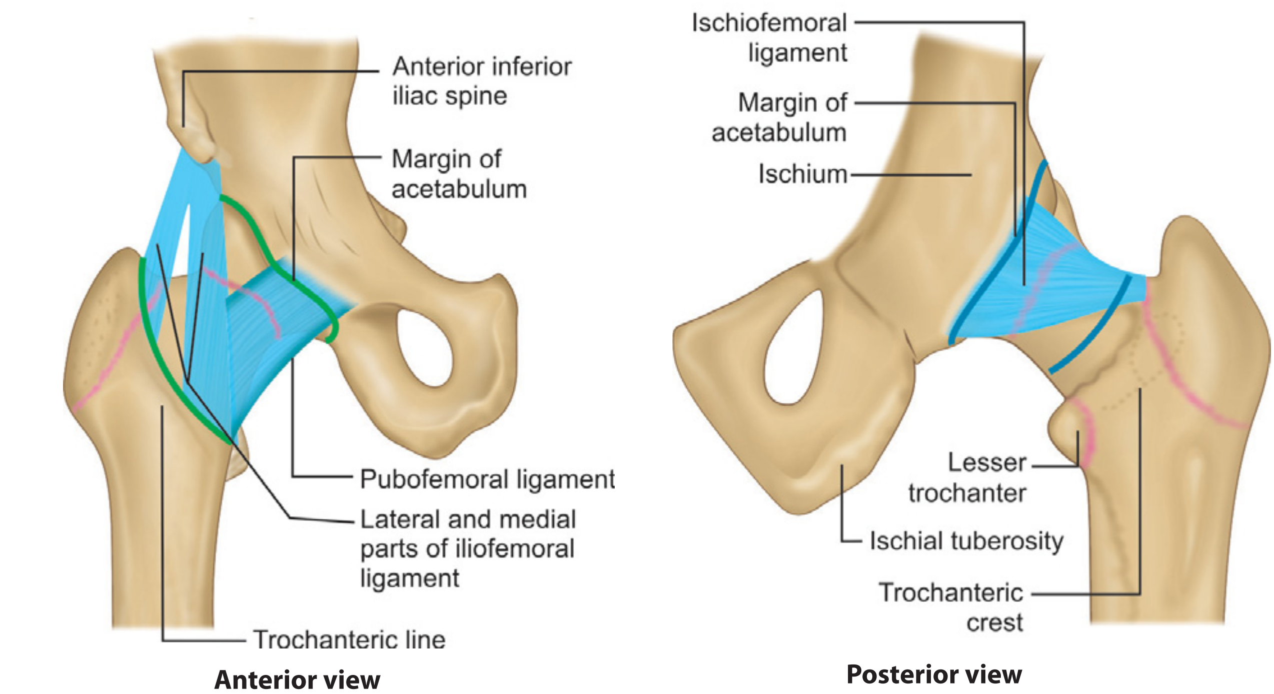


Fig. 46.19 Ligaments around hip joint
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Movement at hip joint:*
  – *The prime mover of hip joint is as follows:*

> - *Flexion*: Psoas major and illacus
> - *Extension*: Gluteus maximus and hamstrings
> - *Abduction*: Gluteus medius and gluteus minimus
> - *Adduction*: Adductor longus, brevis and magnus
> - *External rotation*: Piriformis, superior gemelli, obuturator-internus, inferior gemelli, obuturator-externus, quadratus-femoris.
> - *Internal rotation*: Tensor facia lata, gluteus medius, gtuteus minimus.

- *Points of orthopedic significance:*
  – *Femoral* ***(Scarpa's)*** *triangle (Fig. 46.20):*
    - *Boundaries:*
      - *Lateral side:* Medial border of sartorius
      - *Medial side:* Medial border of adductus longus
      - *Base:* Inguinal ligament
      - *Floor:* Iliacus, psoas major, pectineus, adductor longus
      - *Roof:* Skin, superficial facia, deep facia.
    - *Content:*
      - Femoral artery and its branches
      - Femoral vein and its tributaries
      - Femoral seath enclosing femoral vessel
      - Nerves like femoral nerve, posterior cutaneous nerve thigh, femoral branch of genitofemoral nerve
      - Deep inguinal lymph node.
  – *Abductor lever arm mechanism at hip joint:* Type 1 lever, e.g. Scissor (Fig. 46.21)
    - *Effort (power)*—gluteus medius and gluteus minimus
    - *Fulcrum*—hip joint of femur
    - *Weight*—weight of lower limb
    - *Lever arm*-neck length.

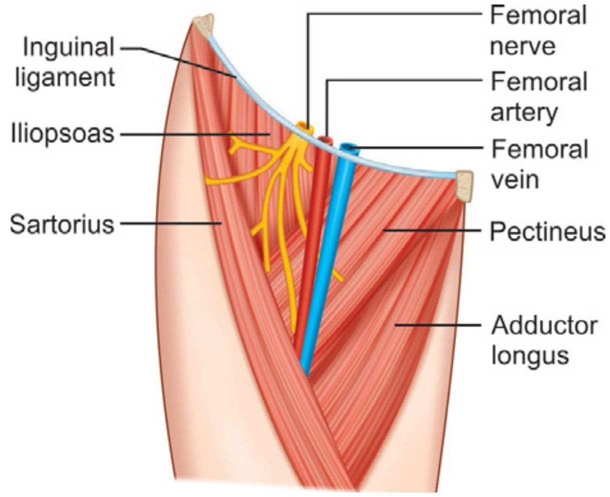


Fig. 46.20 Femoral (Scarpa's) triangle (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

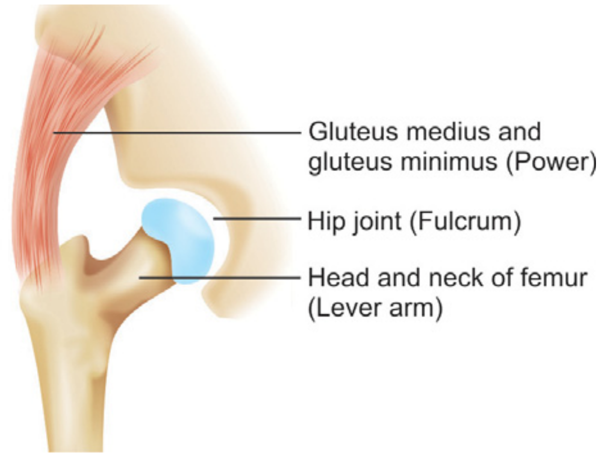


Fig. 46.21 Abductor lever arm mechanism at hip joint

KNEE JOINT

- *Joint type:* Condylar type
- *Joint capsule (Figs 46.22A and B):*
  – *Capsule attachment:*
    - In femur—run 5–10 mm away from articular margin.
    - In tibia—along margin of condyle.
  – *There are deficiency in capsule at three places:*
    - *Anterior part of femur:* For patella and quadriceps
    - *Anterior part of tibia:* For ligamentum patellae.
    - *Posterolateral part of tibia:* For popliteus tendon.
- *Ligaments around knee joint (Figs 46.23A and B)*:
  – *Ligamentum patellae:* (7.5 cm × 2 cm).

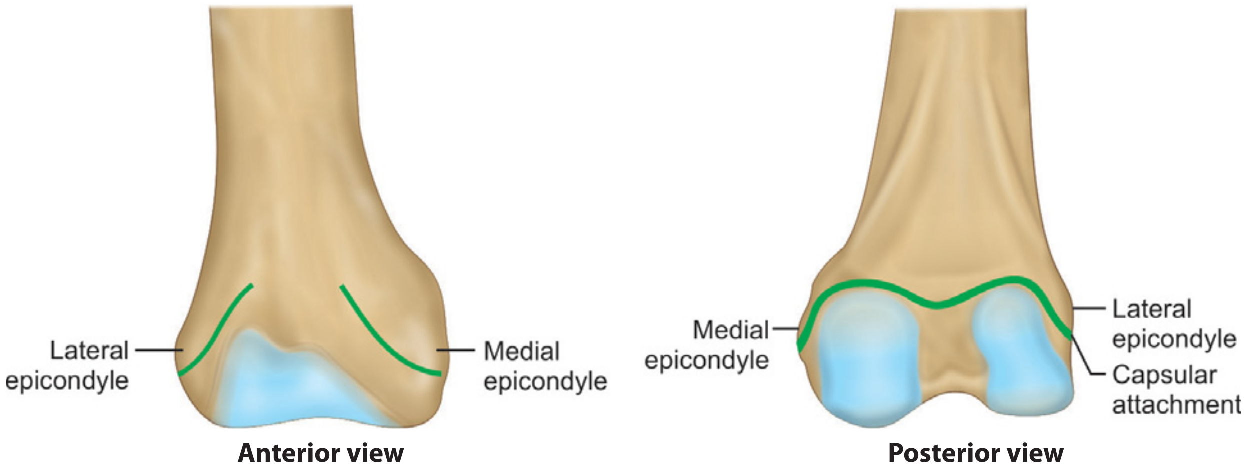


Fig. 46.22A Capsular attachment around disital femur
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

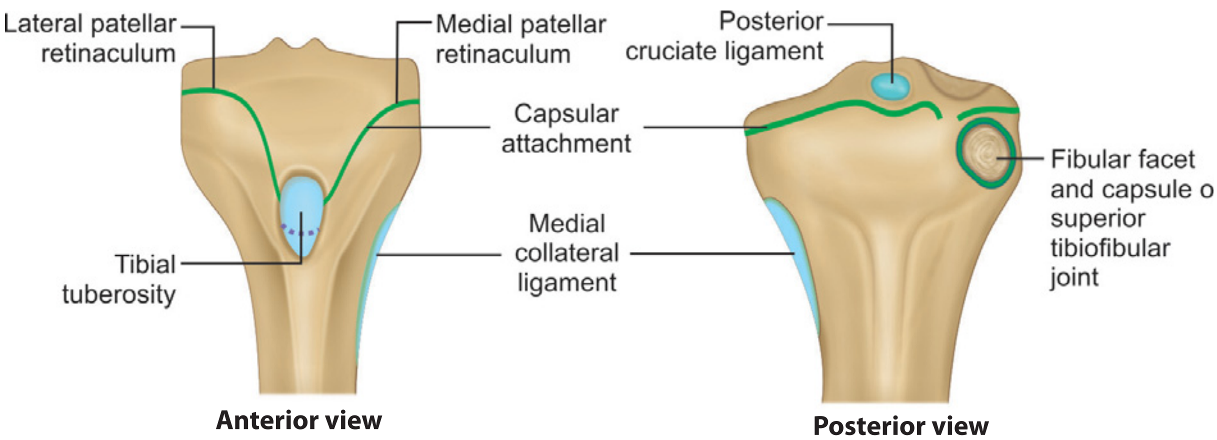
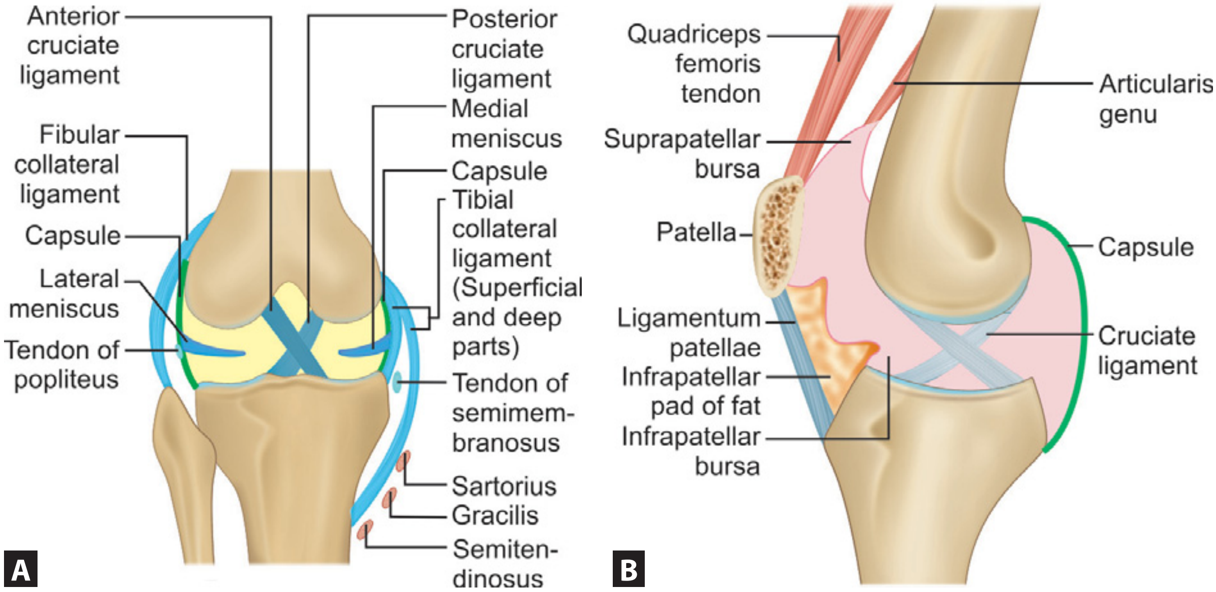


Fig. 46.22B Capsular attachment around proximal tibiar
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- *Medial collateral ligament (tibial collateral):* Two layers superficial and deep.
- *Lateral collateral ligament (fibular collateral):* Tendon of biceps lies in the sleeve of fibular collateral ligament.
- *Anterior cruciate ligament:* Foot print: from anterior part of intercondylar area of tibia platue—upward, backward and laterally—to posterior part of medial surface of lateral femoral condyle.
- *Posterior cruciate ligament:* Foot print: from posterior extreme of intercondylar area of tibia platue—upward, forward and medially—to anterior part of medial surface of lateral femoral condyle.
- *Medial meniscus:* Semicircular.
- *Lateral meniscus:* Circular.
- *Transverse ligament:* Connecting anterior end of both menisci.
- *Coronary ligament:* Capsular condensation attaches meniscus to tibia.
- *Meniscofemoral ligament:*
  - Ligament of **Humphrey**—lies anterior to cruciate ligament.
  - Ligament of **Wrisberg**—lies posterior to cruciate ligament.
- *Posterior oblique ligament:* Thickening of medial capsule.
- *Oblique-popliteal ligament:* One expansion of semi-membranosus muscle.
- *Arcuate ligament:* Condensation of fibers of origin of popliteus muscle.



Figs 46.23A and B Ligaments around knee joint
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

Order of attachment of structure on tibial plateau: (photo)
Mnemonic from anterior to posterior
- *Medical:* M—anterior horn of medial meniscus
- *College:* C—anterior cruciate ligament
- *Lahore:* L—anterior horn of lateral meniscus
- *Lahore:* L—posterior horn of lateral meniscus
- *Medical:* M—posterior horn of medial meniscus
- *College:* C—posterior cruciate ligament.

- *Movement at knee joint:*
  - *The prime mover of knee joint is as follows:*

- *Flexion:* Semitendinosus, semimembranosus, biceps femoris
- *Extension:* Quadriceps femoris

When knee 90° flexed

- *External rotation:* Biceps femoris
- *Internal rotation:* Semimembranosus, semitendinosus, popliteus.

- *Points of orthopedic significance:*
  - *Knee joint complex:* It comprises two joint:
    - Tibiofemoral joint
    - Patellofemoral joint
  - *Screw home mechanism of knee:*
    - *In closed chain (when foot touches the ground):* There is internal rotation of femur in last 30°of knee extension; but in open chain (when foot is off the ground). There is external rotation of tibia to produce the same effect. This rotation is on an about 10°.
    - *Why:* The anteroposterior diameter of medial condyle of femur is more than the lateral condyle. During knee extension when lateral condyle of femur is fully occupied; the part of medial condyle is still unoccupied. The above two activity, i.e. internal rotation of femur or external rotation of tibia take place for full occupancy of medial condyle. This is also called locking of knee. The opposite movement (unlocking of knee) takes placing during knee flexion.
    - Here quadriceps femoris and popliteus are main contributor in locking and unlocking of knee respectively.
  - *Extensor mechanism of patella:* (Fig. 46.24)
    - Power—quadriceps pull
    - Fulcrum—center of rotation of knee

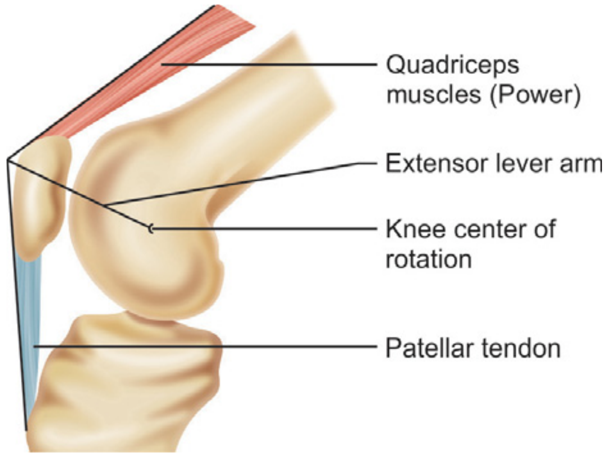


Fig. 46.24 Extensor mechanism of patella

- Weight—leg
- *Lever arm:* The length of extensor lever arm varies with various degree of knee flexion. It is maximum when knee is 20° flexed.

– Position of patella, i.e. articulation with femur in different knee position

- *Lower part—extension:* (0°)
- *Middle part—early flexion:* (30°–60°)
- *Upper pair—mid flexion:* (90°)
- *Medial strip—full flexion:* (120° beyond)

ANKLE JOINT

- *Joint type:* Hinge type.
- *Joint capsule (Fig. 46.25):*
  – *Capsule attachment:* Run along the articular margin with two aberrant attachment
    - *Anteriorly:* It attaches with dorsum of neck of talus.
    - *Posterioly:* It attaches with transverse inferior tibiofibular ligament.
- *Ligaments around ankle joint (Figs 46.26A and B):*
  – Deltoid ligament—(tibia to tarsal bones)
    - *Superficial:* Anterior-tibionavicular, middle-tibiocalcaneal, posterior-tibio-talar.
    - *Deep:* Anterior tibiotalar.
  – Lateral ligament—(tarsal bones to fibula)
    - Anterior talofibular
    - Calcaneofibular
    - Posterior talofibular.

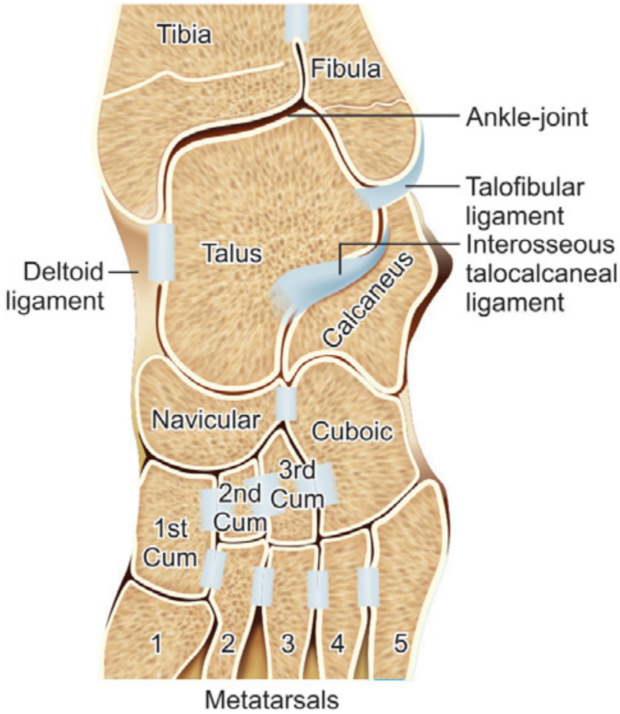


Fig. 46.25 Capsule around ankle and section of ankle and tarsal joints showing capsular extention

  – *Ligaments contributing in syndesmotic joint:*
    - Anteroinferior tibiofibular ligament
    - Posteroinferior tibiofibular ligament
    - Interosseous tibiofibular
    - Transverse inferior tibiofibular.
- *Movement around ankle joint:*
  – The axis of movement at ankle joint 20°–25° oblique to the frontal plane.

- *Dorsi flexion*: Tibialis anterior and supported by all muscles of anterior compartment of leg.
- *Plantar flexion*: Gastrocnemius, soleus and supported by all muscle of posterior compartment of leg.

  – The axis of movement at subtalar (talo-calcaneal) joint passes obliquely from calcaneal tuberosity to superomedial aspect of talus neck.

Inversion: Tibialis anterior, tibialis posterior

Eversion: Peroneus longus, peroneus brevis

  – Supination and pronation are position of foot which are acquired by the combined movement at ankle, subtalar and midtarsal joints.

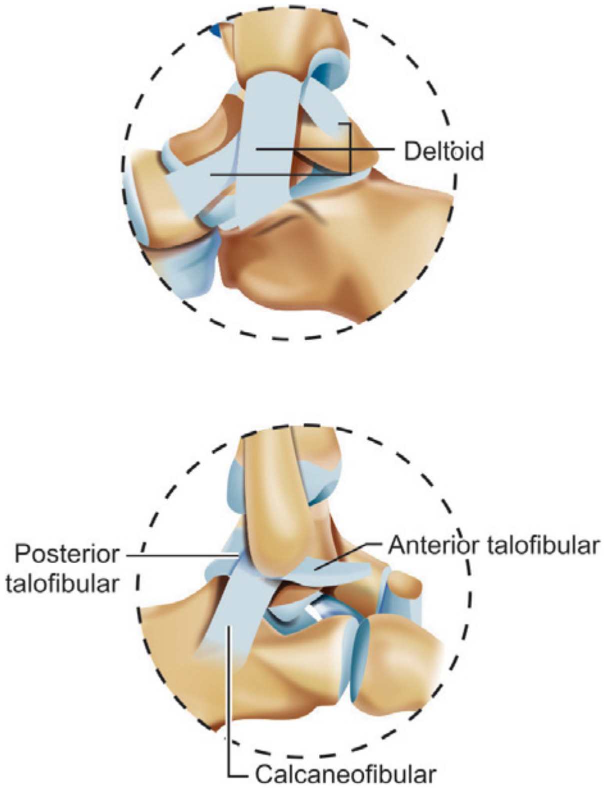


Fig. 46.26A Ligaments around ankle joint (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

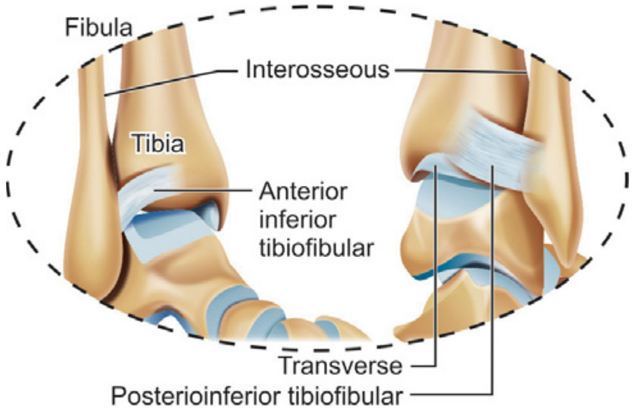


Fig. 46.26B Ligaments around ankle joint (*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

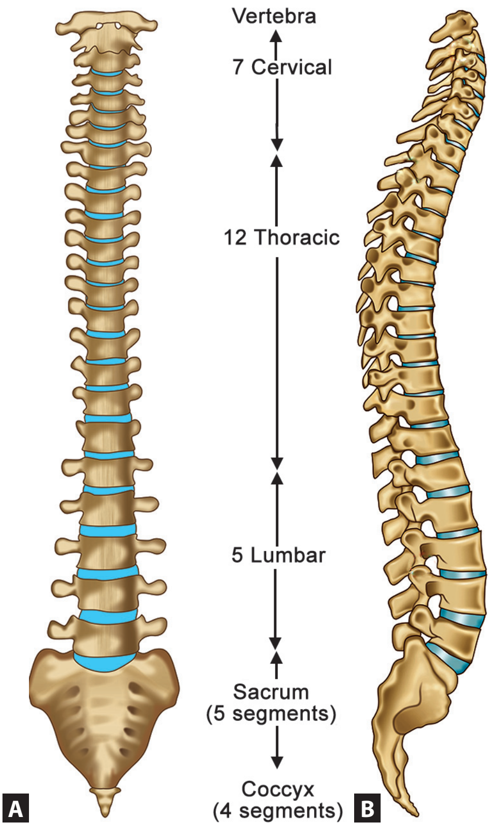
- *Points of orthopedic significance:*
  - *Ankle joint complex:* It comprises two joints
    - Tibiotalar joint
    - Inferior tibiofibular joint
  - *Ankle mortise:* It is a bony arch formed by medial malleoli, tibial plafond, and lateral malleoli. Mortise is strengthen by syndesmotic ligament.

CHAPTER

47

Bones and Joints of Spine

- *Structure of spine column (Figs 47.1A and B):*

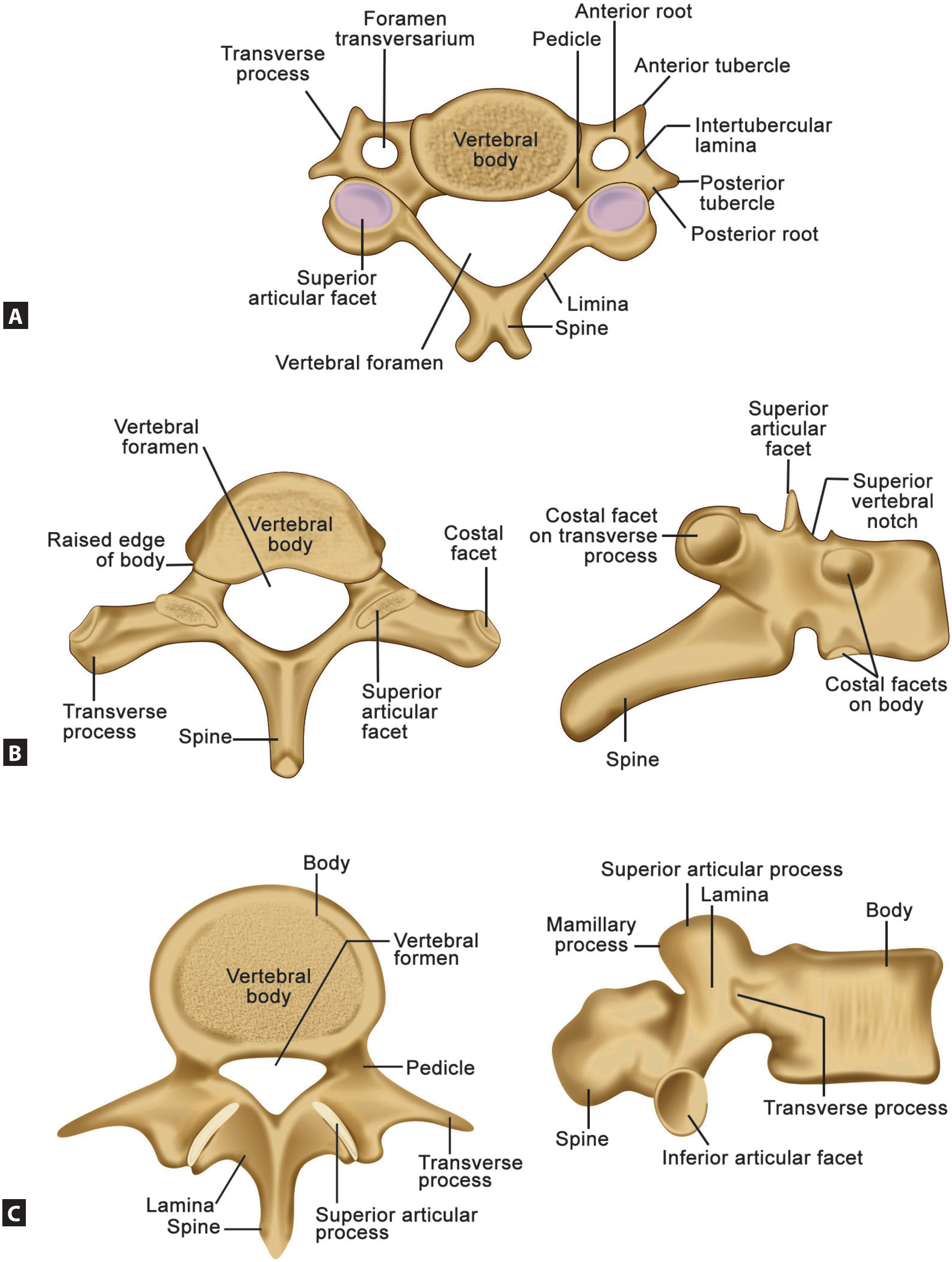


Figs 47.1A and B Structure of spinal column. (A) Anteroposterior view; (B) Lateral view
Courtesy: Inderbir Singh's Textbook of Human Anatomy

- *Morphology of typical spine (Figs 47.2A to C):*

Comparison of cervical, dorsal and lumbar vertebrae			
Points	*Cervical*	*Thoracic*	*Lumbar*
Shape of body	Quadrangular	Heart shaped	Kidney shaped
Spinous-process	Bifid	Long and pointed	Short, blunt and broad
Articular facets	Almost horizontal	Coronal plane lie	Sagittal plane lie
Transverse process:			
• Costal element	Anterior tubercle	Ribs	Transverse process proper
• Transverse element	Posterior tubercle	Transverse process proper	Accessory process
Others	Foramen transversarium for vertebral artery	Costal facet on vertebral body and transverse process	Mammillary body–a tubercle over posterior aspect of superior facet

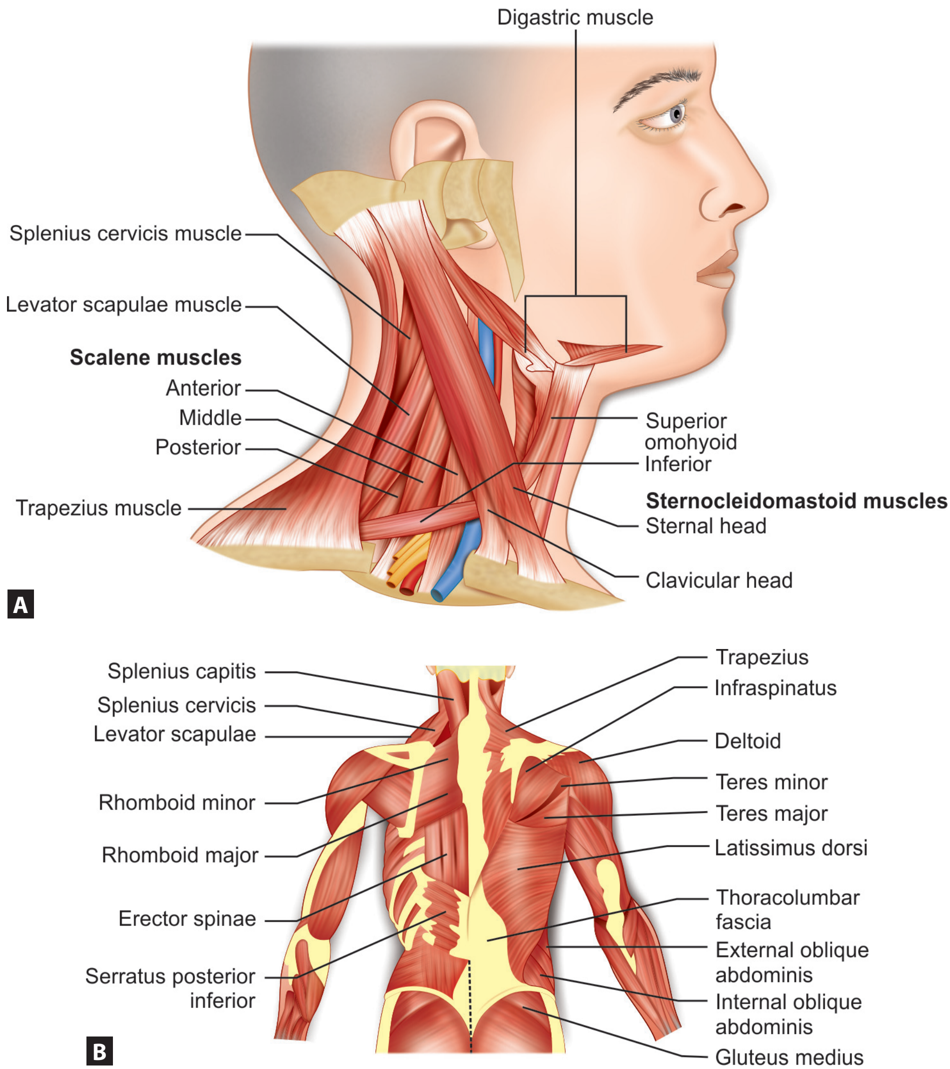
- *Ossification center:*



Figs 47.2A to C Typical spine. (A) Typical cervical spine; (B) Typical dorsal spine; (C) Typical lumbar spine
Courtesy: Inderbir Singh's Textbook of Human Anatomy

- *Primary:* 3,
  - 1 for vertebral body
  - 2-one for each half of neural arch
- *Secondary:* 5
  - 1 for tip of spinous process
  - 2-one for each tip of transverse process
  - 2-ring epiphyses each at upper and lower surface of body.

- *Muscles of neck and back (Figs 47.3A and B):*
  - It may be classified as superficial and deep group.
    - *Superficial muscles:* Trapezius, deltoid, infraspinatus, teres minor + major, latissimus dorsi, external oblique abdominis, internal oblique abdominis, gluteus medius
    - *Deep muscle:* Splenius capitis, splenius cervicis, levator scapulae, rhom-



Figs 47.3A and B Muscles of neck and back

boidus minor + major, erector spinae, serratus posterior.

– It may be devided into four group according to their function:

1. *Semispinalis group:*
   – Attaches vertebrae to vertebrae
   – Do extension of neck
2. *Erector spinae group:*
   – These muscles are arranged in three column and ranges from ribs to sacrum
   – Do extension of vertebral column
3. *Multifidus group:*
   – Attaches vertebrae to vertebrae
   – Do rotation of vertebrae
4. *Quadratus lumborum group:*
   – Attaches 12 rib to ileum
   – Do lateral flexion of spine

- *Joints in spine (Fig. 47.4):*
  – *Three major joint types are present in spine:*
    - *Symphysis joint:* In between body of vertebrae
    - *Zygapophyseal joint:* In between facets of articular process
    - *Uncovertebral joints* are present in posterolateral part of cervical spine.
- *Important ligaments in spine (Fig. 47.4):*
  – Anterior longitudinal ligament
  – Posterior longitudinal ligament
  – Ligamentum flavum
  – Interspinous ligament
  – Supraspinous ligament

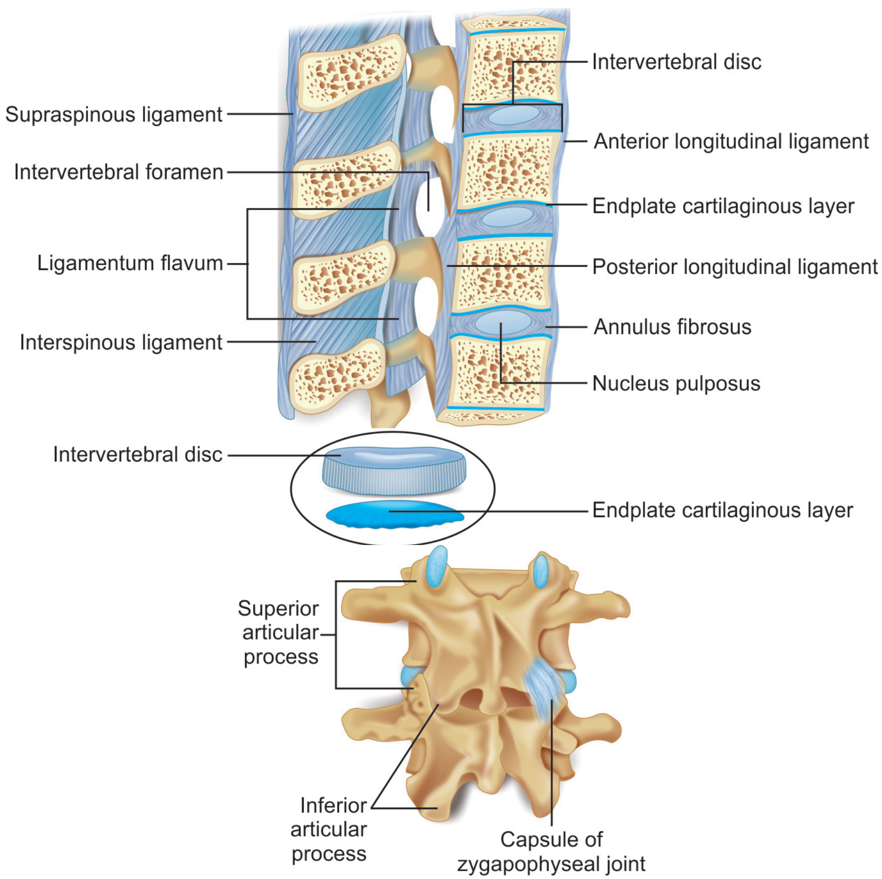


Fig. 47.4 Joints and ligaments in spine

- *Movements in spine:*
  - Three types of movements are possible in spine:

Movements in spine			
Points	*Cervical spine*	*Thoracic spine*	*Lumbar spine*
1. Flexion and extension	Present (maximum at atlanto-occipital joint)	Minimal	Present
2. Lateral flexion	Present (maximum at atlanto-occipital joint)	Minimal	Present
3. Rotation	Only at atlanto-axial joint	Present	Minimal

- *Function of spine:*
  - *Following important function are being performed by spine:*
    - Maintain upright position of body
    - Support pectoral and pelvic girdle
    - Act as shock absorber
    - Provide attachment to rib cage
    - Allows various type of body movement
    - Protect spinal cord and nerve root.
- *Points of orthopedic significance:*
  - *Fascia colli:* This is deep facia of neck found in different form (Fig. 47.5).
    - *Investing layer:* Deep to platysma and cover the neck like collar
    - Pretracheal fascia
    - Prevertebral fascia
    - Carotid seath
  - *Anterior triangle of neck:* Bounded anteriorly by median plane, posteriorly by sternocleidomastoid and superiorly by base of the mandible.
  - *Posterior triangle of neck:* Bounded anteriorly by posterior border of sternocleidomastoid, posteriorly by anterior border of trapezius and base is formed by medial third of clavicle.
  - *Triangle of auscultation:* Bounded medially by lateral border of trapezius by medial border of scapula and inferiorly by the upper border of latissimus dorsi.
  - *Renal angle:* The angle between lateral margin of lumbar spine and inferior border of 12th rib.
  - ***Petit's** triangle:* Bounded medially by lateral border of latissimus dorsi, laterally by posterior border of external oblique muscle and inferiorly by iliac crest; a site of lumbar hernia.
  - *Sacral hiatus:* Used for caudal block.

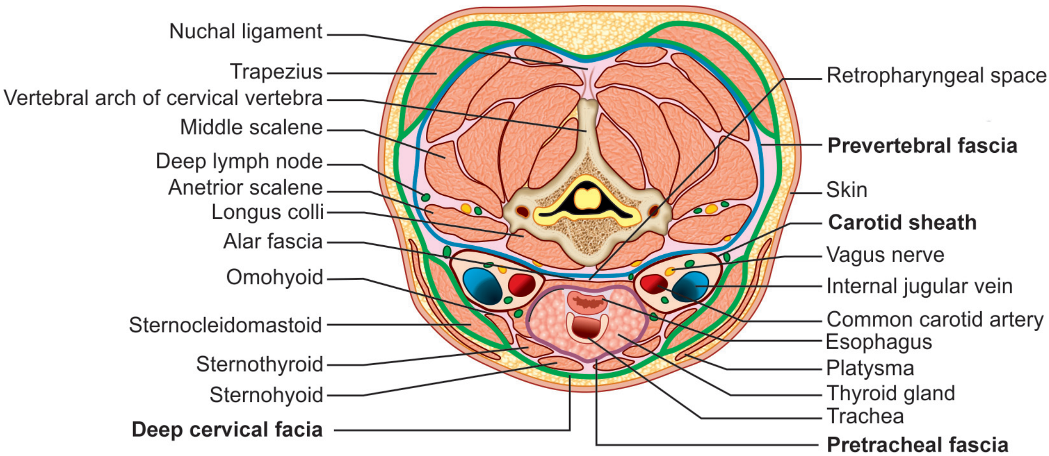


Fig. 47.5 Transverse section of neck showing fascia colli
Courtesy: Inderbir Singh's Textbook of Human Anatomy

CHAPTER

48

Specimen Section

PROCEEDING FOR SPECIMEN SECTION

- Say in single sentence, sir this is formalin mounted specimen of..(......) showing
  - Bone…e.g. tibia/femur
  - Region…e.g. knee
- *Examiner expectations from specimen:*
  - Identify this specimen?
  - Identify the structures seen in specimen?
  - Describe the gross pathology of specimen if any?
  - Typical microscopic finding of specimen if any?
  - Some clinical question of orthopedic significance?

DISSECTED SPECIMEN OF ELBOW

- *Identification of structure seen in specimen (Figs 48.1A and B)*:
- *Cubital fossa:*
  - *Boundaries of cubital fossa:*
    - Medial side—lateral border of pronator teres
    - Lateral side—medial border of brachioradialis
    - Base—a hypothetical line between two epicondyles of humerus
    - Floor—brachialis and supinator
    - Roof—skin, superficial and deep facia, bicipital aponeurosis
  - *Content of cubital fossa (from lateral to medial)*
    - Radial nerve
    - Biceps tendon with its aponeurosis
    - Brachial artery, radial artery with its recurrent branch, ulnar artery with its recurrent and interosseous branch
    - Median nerve

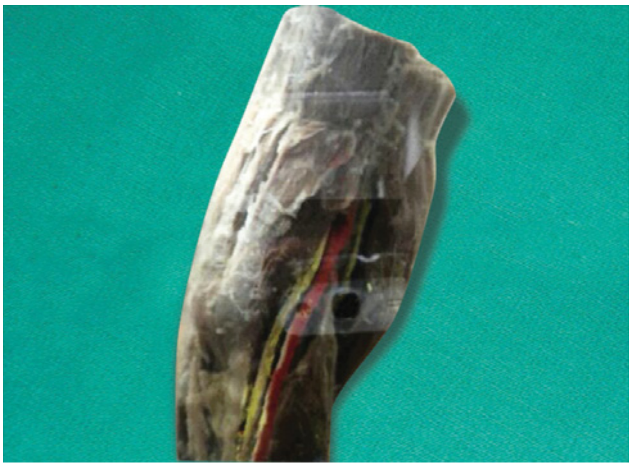


Fig. 48.1A Dissected specimen of elbow (cubital fossa)

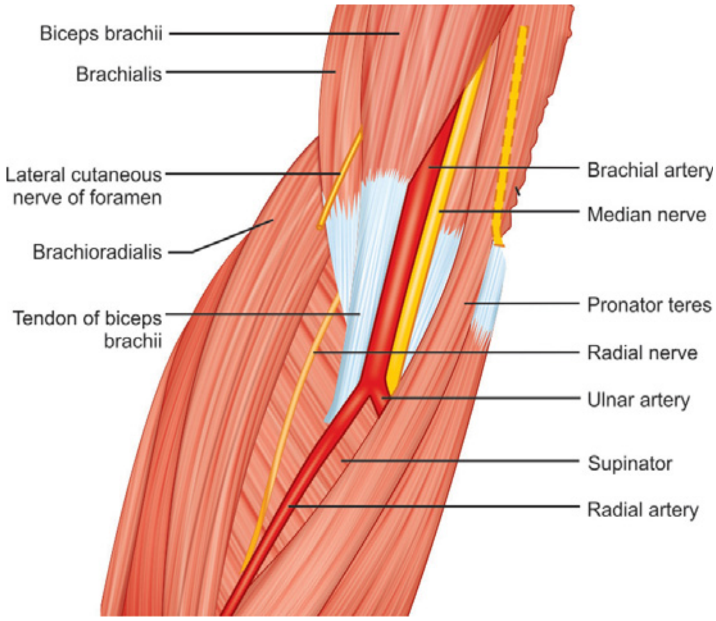
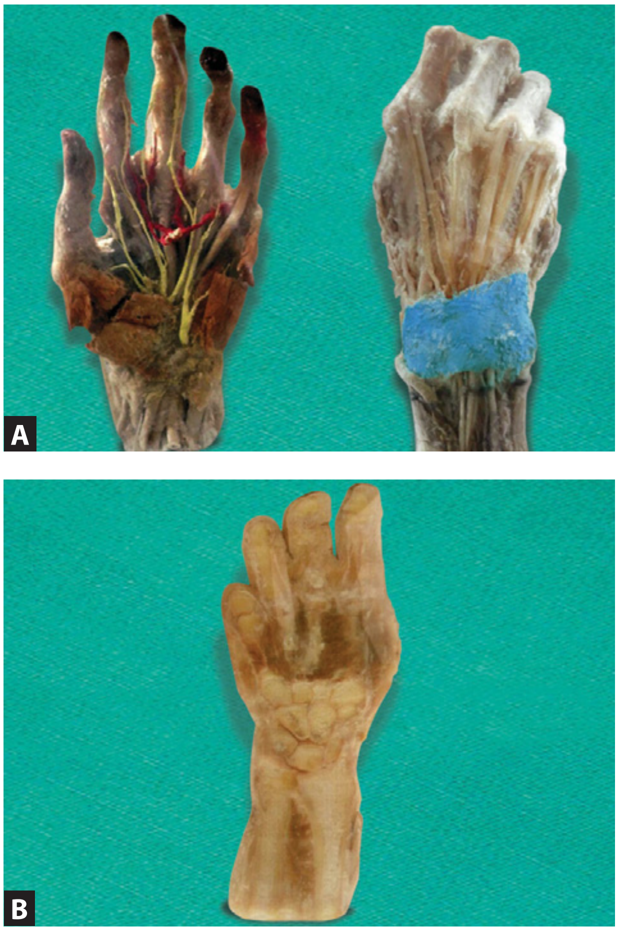


Fig. 48.1B Cubital fossa boundary and content
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

DISSECTED SPECIMEN OF WRIST AND HAND

- *Identification of structure seen in specimen (Figs 48.2A and B)*:
- *Flexor retinaculum (Fig. 48.3):*
  - *Structures passing over flexor retinaculum:*
    - Palmar cutaneous branch of median nerve
    - Palmaris longus tendon
    - Palmar cutaneous branch of ulnar nerve
    - Ulnar artery
    - Ulnar nerve
    - Flexor carpi ulnaris tendon
  - *Structures passing under the flexor retinaculum:*
    - Flexor carpi radialis tendon
    - Flexor pollicis longus tendon
    - Median nerve
    - Flexor digitorum superficialis tendon
    - Flexor digitorum profundus tendon
    - Radial and ulnar bursae
- *Arterial arches in hand*:
  - Arterial arches in hand is result of anastomosis between radial and ulnar artery.



Figs 48.2A and B Dissected specimen of wrist and hand

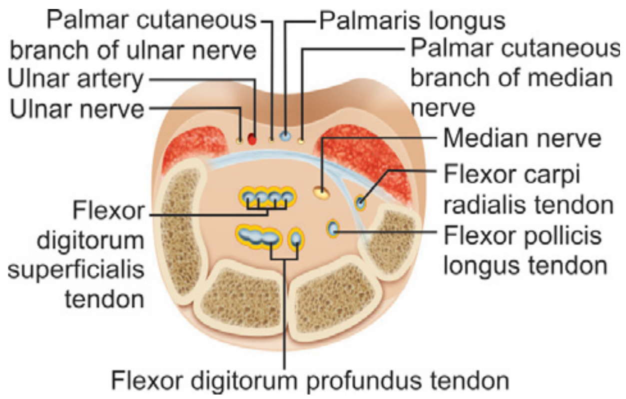


Fig. 48.3 Structure passing over and underneath flexor retinaculum

- *Superficial palmar arch:* Here ulnar artery is chief contributor.
- *Deep palmar arch:* Here radial artery is chief contributor.

- *Layers and spaces of hands:*
  - *Layers of hand:*
    - Skin and subcutaneous tissue.
    - Palmar facia.
    - Flexor tendons.
    - Adductor pollicis
    - Interosseus mucles
  - *Spaces of hands:*
    - Thenar space
    - Midpalmar space
    - Forearm space of parona.

DISSECTED SPECIMEN OF KNEE

- *Identification of structure seen in specimen (Fig. 48.4)*:
- *Popliteal fossa (Fig. 48.5)*:
  - *Boundaries of popliteal fossa:*
    - Superomedial side—semitendinosus and semimembranosus
    - Superolateral side—biceps femoris
    - Inferomedial side—medial head of gastocnemius
    - Inferolateral side—lateral head of gastrocnemius
    - Floor—capsule covering the knee joint and popliteus muscle with its facia
    - Roof—skin, superficial and deep popliteal fascia

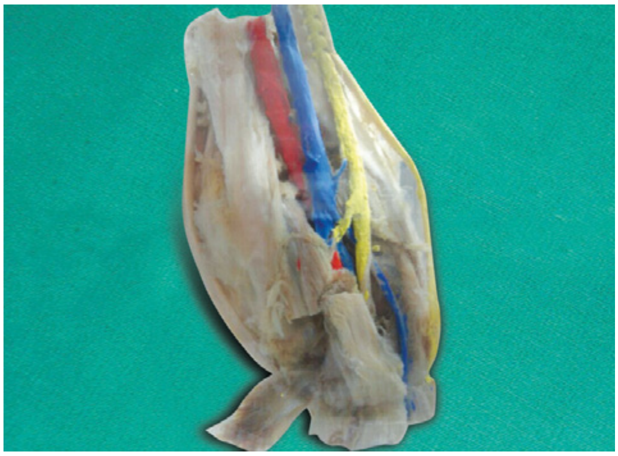


Fig. 48.4 Dissected specimen of knee (popliteal fossa)

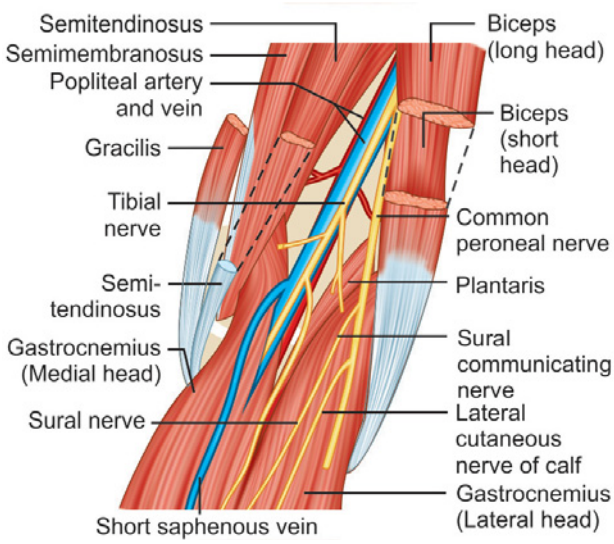
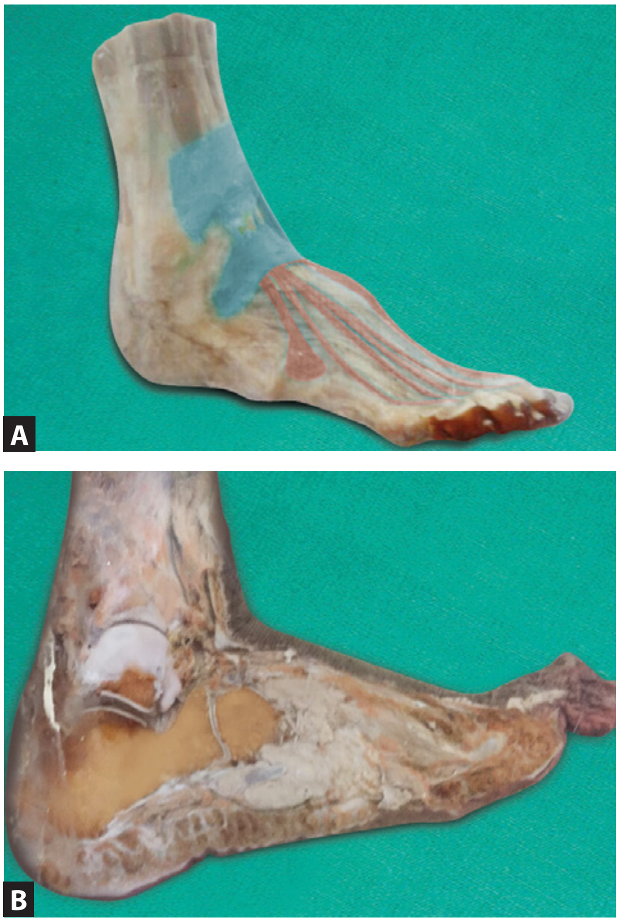


Fig. 48.5 Boundaries and content of popliteal fossa
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

  - *Content of popliteal fossa:*
    - *Artery:* Popliteal artery and its branches
    - *Vein:* Popliteal vein and its tributaries
    - *Nerve:* Tibial nerve, common peroneal nerve and its branches, posterior cutaneous nerve of thigh, genicular branch of obturator nerve.
    - Lymph node

DISSECTED SPECIMEN OR ANKLE AND FOOT

- *Identification of structure seen in specimen (Figs 48.6A and B)*:



Figs 48.6A and B Dissected specimen or ankle and foot

- *Retinaculum around ankle (Figs 48.7A and B):*
  - *Structures passing under extensor retinaculum:* Mnemonic from medial to lateral
    - The—tibialis anterior tendon
    - Himalaya—extensor hallucis longus tendon
    - Are—anterior tibial artery
    - Not—deep peroneal nerve
    - Dry—extensor digitorum longus tendon
    - Places—peroneus tertius tendon
  - *Structures passing under the flexor retinaculum:* Mnemonics from superior to inferior.

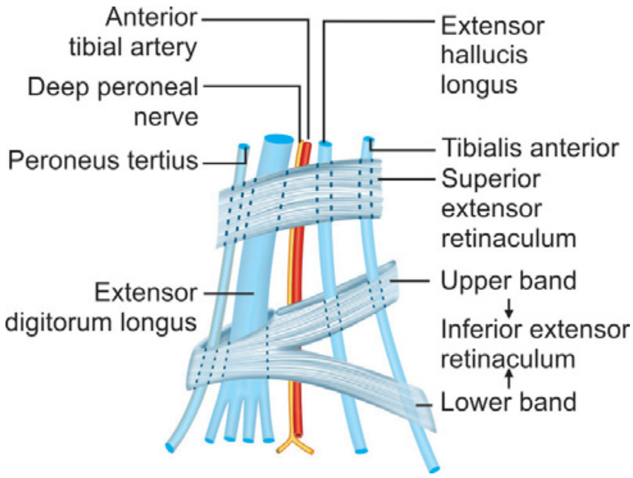


Fig. 48.7A Extensor retinaculum (structure underneath)
Courtesy: Inderbir Singh's Textbook of Human Anatomy

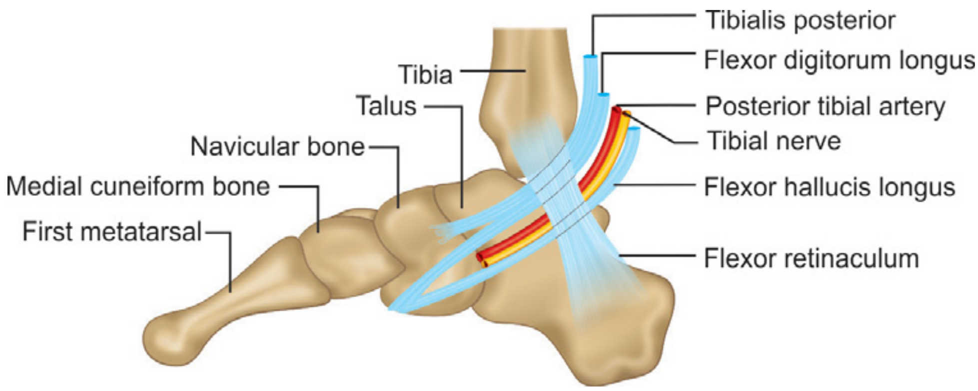


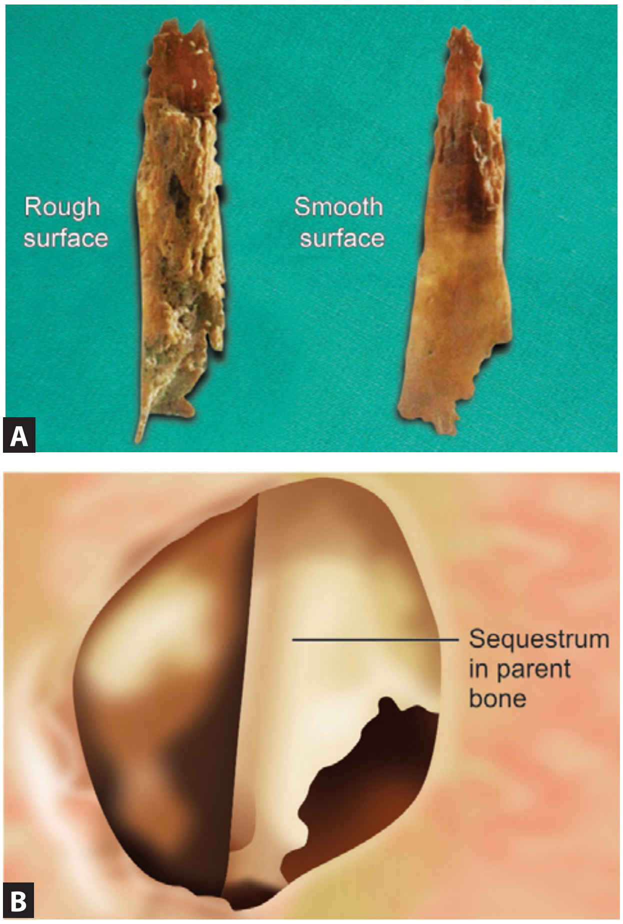
Fig. 48.7B Flexor retinaculum (structure underneath)
(*Courtesy:* Inderbir Singh's Textbook of Human Anatomy)

- The—tibialis posterior tendon
- Doctors—flexor digitorum longus tendon
- Are—posterior tibial artery
- Nerve—tibial nerve
- Happy—flexor hallucis longus tendon

- *Arterial arches in sole of foot:*
  - Plantar arch in sole is continuation of lateral plantar artery, a branch of posterior tibial artery.
  - Medially the arch is completed by dorsalis pedis artery (anterior tibial artery)
- *Layers in sole:*
  - *Layers in sole are as follows:*
    - Skin and subcutaneous tissue.
    - Plantar fascia layer.
    - Flexor tendon layers.
    - Adductor hallucis layer
    - Interosseus layer.

SPECIMEN OF BONY SEQUESTRUM

- *Identification of structure seen in specimen (Figs 48.8A and B)*:
  - Sequestrum is a dead piece of necrotic bone surrounded by infected granulation tissue and pus within a living bone.
- *Localization of sequestrum:*
  - Metaphyseal
  - Diaphyseal
- *Gross feature of sequestrum:*
  - *Morphology of sequestrum:*
    - Irregular piece of bone
    - Surface—smooth pus facing surface and rough surface due to granulation tissue.
  - *Characteristics of sequestrum:*
    - Ivory white color
    - Brittle in nature
    - Sink in water
    - Dull note on percussion
  - *Classification of sequestrum:*



Figs 48.8A and B Specimen of bony sequestrum

- *On the basis of shape:*

Pencil—infants

Cylindrical—infants

Ring—pin tract infections

Conical—amputation stump.

- *On the basis of consistency:*

Coke like or sandy—tuberculosis

Feathery—syphilis

- *On the basis of color:*

Black—calcaneum osteomyelitis

Green—*Pseudomonas* infection.

- *Histopathologic feature of sequestrum:*
  - Closed Volkmann canal

  - No capillary bleeding (paprika sign negative)
- *Sequestrectomy:* Surgical procedure for removal of dead necrotic piece of bone from their parent bone.

SPECIMEN OF POTT'S SPINE

- *Identification of specimen (Fig. 48.9):* Sagittal section of dorsolumbar spine
- *Localization of vertebral tuberculosis:*
  - *Order of involvement of spine:* Dorsal > lumbar > dorsolumbar = cervical > sacral.
  - *Area of predilection of tubercular affection:*
    - Paradiscal
    - Complete

Fig. 48.9 Specimen of Pott's spine (sagittal section of dorso-lumbar spine)

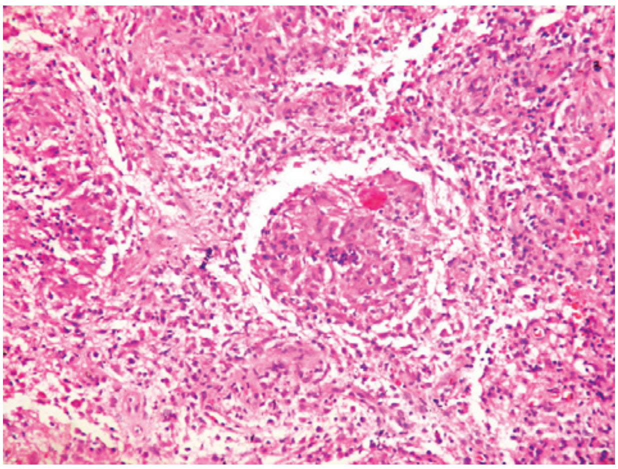


Fig. 48.10 Histopathology of tuberculous lesion (*Courtesy:* Dr Gitika Khanna)

    - Anterior
    - Central
    - Posterior
    - Others like skip lesion, spinal tumor syndrome
- *Gross feature of specimen:*
  - Paradiscal affection
  - Loss of vertebral height of adjacent vertebrae (anterior wedging)
  - Destruction of end plates adjacent to disc
- *Histopathology of tuberculous lesion (Fig. 48.10)*:
  - *Composition of tubercular granuloma:*
    - Lymphocytes
    - Epithelioid cells
    - Multinucleated giant cells
    - Fibrous tissue
    - Central necrosis
  - *Fate of tubercular granuloma:*
    - Caseous necrosis and cold abscess
    - Development of sinus lined by granulation tissue
    - Granuloma coalesce to form tuberculoma
    - Dystrophic calcification
- *Surgical procedure for Pott's spine:*
  - Aspiration of pus
  - Abscess drainage
  - Debridement of disease and decompression of cord
  - Spinal stabilization.

SPECIMEN OF MENISCI

- *Identification of specimen (Fig. 48.11):*
  - Meniscus is crescentic disc present between condyle of femur and tibia.
  - *It serves the following function:*
    - Menisci provide the depth to the condylar knee joint.
    - They ensures the smooth gliding of femoral condyle during knee motion.
    - They act as shock absorber.
    - Joint lubricator action.
- *Gross feature of meniscus:*
  - *Anatomy of meniscus:*
    - Two horn anterior or posterior
    - Outer convex and thicker and inner concave and thinner border

- Superior concave and inferior flat surface

Comparison between medial and lateral meniscus		
	Medial meniscus	*Lateral meniscus*
Shape	Semicircular	Circular
Mobility	Less mobile	More mobile
Prone to injury	More prone	Less prone
Relation with adjacent structure	Attached with tibial collateral ligament	Adherence with tendon of popliteus and meniscofemoral ligament

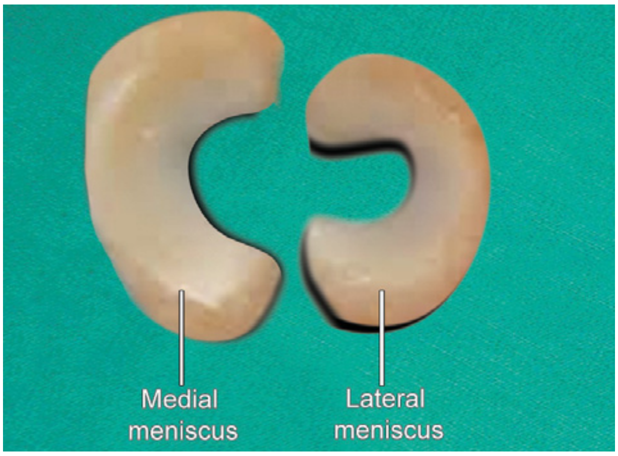


Fig. 48.11 Specimen of medial and lateral menisci

- *Histopathologic feature of meniscus (Fig. 48.12):*
  - Fibrocartilage
  - *Vascular zoning of meniscus* (Miller, Warner and Harner)
    - Red zone—peripheral 3 mm, vascular
    - Red-white zone—3 to 5 mm from periphery, borderline vascularity
    - White zone—after 5 mm from periphery, avascular
- *Common pathologies of meniscus:*
  - Meniscal tear-**O'Connor** classification of meniscal tear

Longitudinal
Horizontal
Oblique
Radial
Complex tear

  - *Cold meniscal pathology:*
    - Discoid meniscus—lateral more common
    - Meniscal cyst
- *Meniscotomy:* Open or arthroscopic, partial or complete.

SPECIMEN OF LOOSE BODIES

- *Identification of specimen (Fig. 48.13):* Loose bodies are foreign bodies found in joint

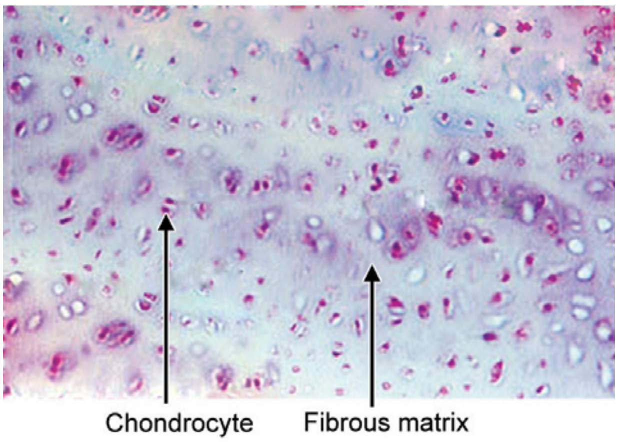


Fig. 48.12 Histopathology of fibrocartilage

Fig. 48.13 Specimen of loose bodies

cavities as a result of various pathologic processes.

- *Joint involvement:* Knee > hip > shoulder > ebow
- *Gross feature of loose bodies:*
  - Shape—irregular
  - Size—various
  - Color—white, brown, reddish
  - Surface—smooth
  - Consistency—soft, firm, hard
- *Histopathology of loose bodies (Fig. 48.14):*
  - Central cartilaginous material with focal enchondral ossification

Pathological variants of loose bodies
• *Osteochondral:*
Osteochondral fracture
Osteochondritis dessicans
Synovial chondromatosis
Osteoarthritic osteophytes
Neuropathic osteophytes
• *Chondral:*
• *Fibrinous:*
Hemorrhagic
Tubercular (rice bodies)
Rheumatoid and degenerative arthritis
• *Unclassified:*
Introduced foreign bodies
Lipoma
Angioma

- *Removal of loose bodies:* Open or arthroscopic.

SPECIMEN OF OSTEOCHONDROMA

- *Identification of specimen (Fig. 48.15):*
  - Excised exostosis and its section
  - *Age group:* 2nd decade
- *Bone involvement:*
  - Distal femur > proximal tibia > proximal humerus
  - Outgrowth may be sessile or pedunculated/solitary or multiple
- *Gross feature of specimen:*
  - Grey-white tumor
  - Broad or narrow base
  - Mushroom shaped
  - *Section shows:* Cortical bone and bone marrow enclosed within cartilaginous cap
- *Histopathology of osteochondroma (Fig. 48.16):*
  - Hamartomatous lesion metaphyseal in origin
  - Outer mature cartilage resembling epiphyseal cartilage.
  - Inner mature lamellar bone and bone marrow.
- *Surgical procedure for osteochondroma:* Extraperiosteal resection of exostosis (excise the whole exostosis along with periosteum).

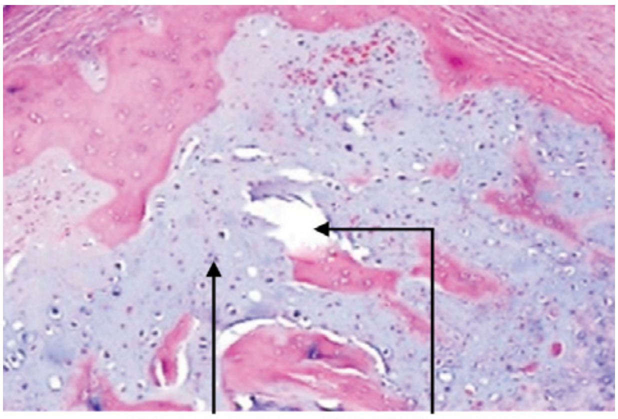


Fig. 48.14 Histopathology of loose bodies (*Courtesy:* Dr Gitika Khanna)

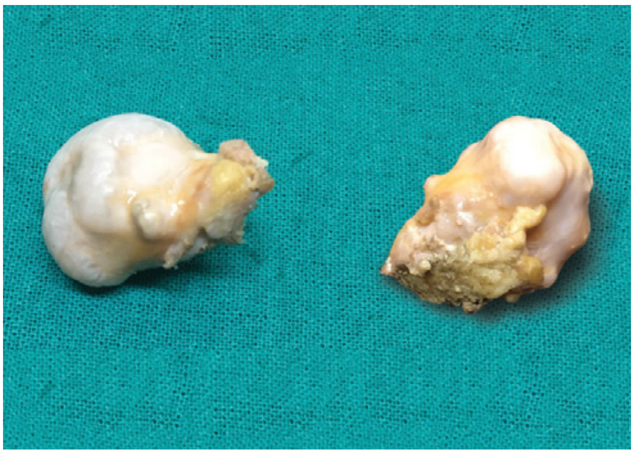


Fig. 48.15 Specimen of osteochondroma

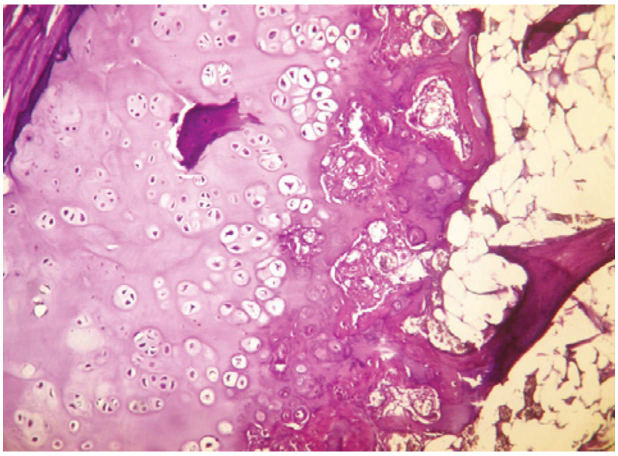


Fig. 48.16 Histopathology of osteochondroma

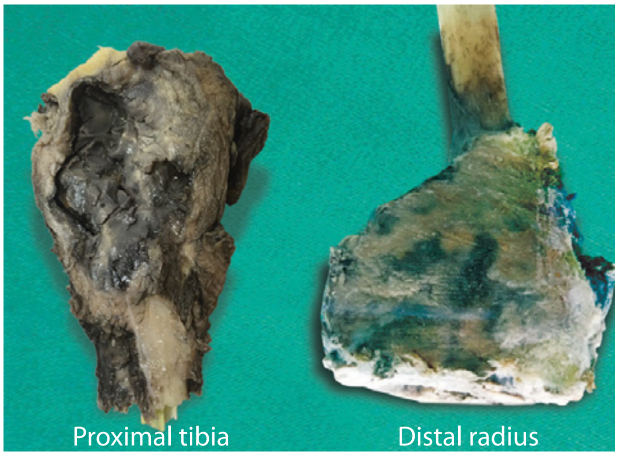


Fig. 48.17 Specimen of giant cell tumor

SPECIMEN OF GIANT CELL TUMOR

- *Identification of specimen (Fig. 48.17)*:
  - Excised giant cell tumor-section
  - *Age group:* 20–40 year
- *Bone involvement:* Distal femur > proximal tibia > distal radius
- *Gross feature of specimen:*
  - Gray-white well circumscribed tumor.
  - Expanded and eccentrically placed.
  - Covered by thin shell of subperiosteal bone.
  - *Section shows:*
    - Hemorrhagic, necrotic and honey-combed appearance
- *Histopathology of giant cell tumor (Fig. 48.18)*:
  - Epiphyseal origin
  - Multinucleated giant in the matrix of mononuclear spindle cells.
  - Nuclei of giant cell are similar to mononuclear cells.

Jaffe's *histological grading:*

- Grade-1—numerous giant cells and fewer spindle cells.
- Grade-2—fewer giant cells with more spindle cells.
- Grade-3—rare giant cells with numerous spindle cells.

  - Other tumor containing giant cell, the nuclei of these giant cells are not similar to their stromal cells. Use a famous mnemonic—FOGMACHINES

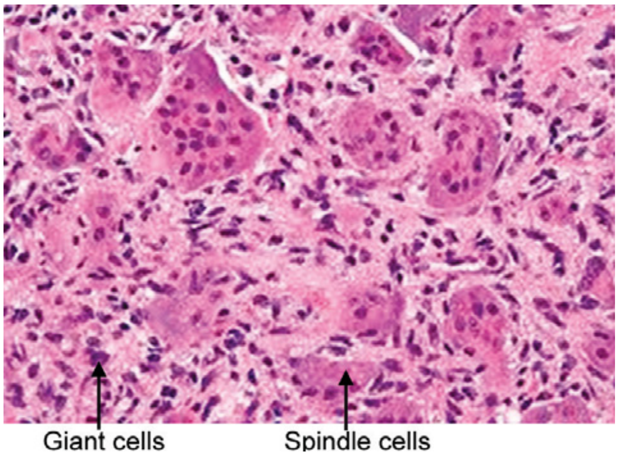


Fig. 48.18 Histopathology of giant cell tumor (*Courtesy:* Dr Gitika Khanna)

F—fibrous dysplasia
O—osteoblastoma
G—giant cell reparative granuloma
M—metastases and multiple myeloma
A—aneurysmal bone cyst
C—chondroblastoma and myxoid fibroma
H—histiocytoses and hyperparathyroidism
I—infection
N—nonossifying fibroma
E—enchondroma
S—solitary bone cyst

- *Surgical procedure for giant cell tumor:*
  - Extended curettage—when curettage is followed by cauterization by following ways
    - Phenol
    - Liquid nitrogen
    - Burr

- Electrical
- Argon laser
- Dead space management with bone graft (autograft and allograft), bone substitute, bone cement
- En block excision and reconstruction by turn-o-plasty or bone grafting.

SPECIMEN OF OSTEOSARCOMA

- *Identification of specimen (Fig. 48.19):*
  - Wide resection osteosarcoma-section
  - *Age group:* primary—2nd decade, secondary—5th decade
- *Bone involvement:*
  - Distal femur > proximal tibia > proximal humerus
  - *Distribution of tumor in bone:*
    - Intramedullary (conventional)
    - Periosteal
    - Parosteal
- *Gross feature of specimen:*
  - Gray-white tumor
  - Bulky mass is encapsulated by fibrous tissue.
  - *Section shows:*
    - Cortical breaching and periosteal elevation—(Codman's triangle)
    - Multiple necrotic and hemorrhagic focci.
- *Histopathology of osteosarcoma (Fig. 48.20):*
  - Metaphyseal origin
  - Malignant osteoid matrix formation by malignant spindle cells.
  - *Various type of cellular distribution:*
    - Osteoblastic
    - Chondroblastic
    - Fibroblastic
    - Small cell
    - Telangiectactic
- *Surgical procedure for osteosarcoma:*
  - Wide resection of tumor with limb salvage surgery
  - Amputation of limb.

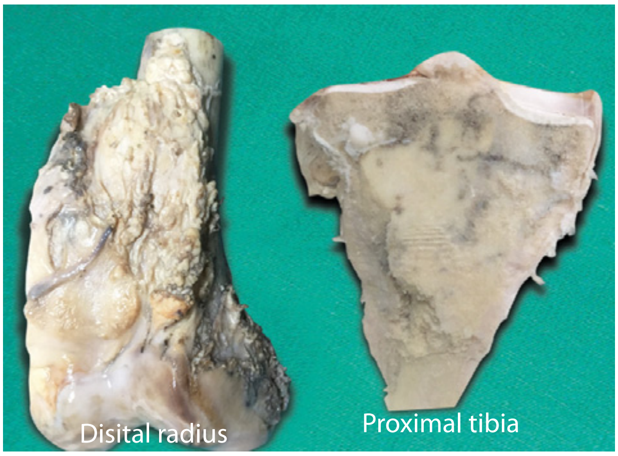


Fig. 48.19 Specimen of osteosarcoma

SPECIMEN OF EWING'S SARCOMA

- *Identification of specimen (Fig. 48.21):*
  - Excised Ewing's sarcoma-section
  - *Age group:* 1st to 3rd decade-most common age 5–15 year
- *Bone involvement:* Femur, tibia, shoulder, pelvis

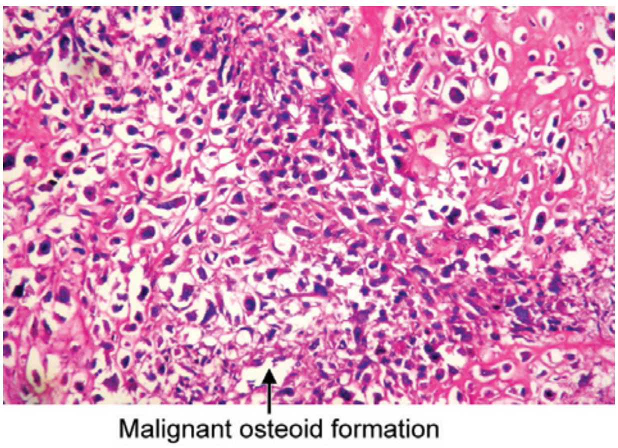


Fig. 48.20 Histopathology of osteosarcoma (*Courtesy:* Dr Gitika Khanna)

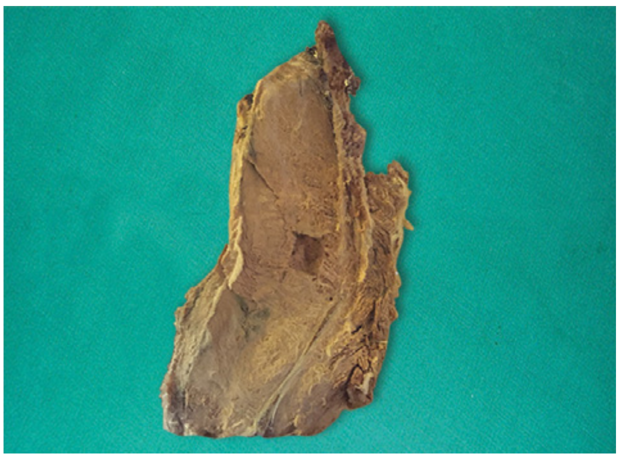


Fig. 48.21 Specimen of Ewing's sarcoma

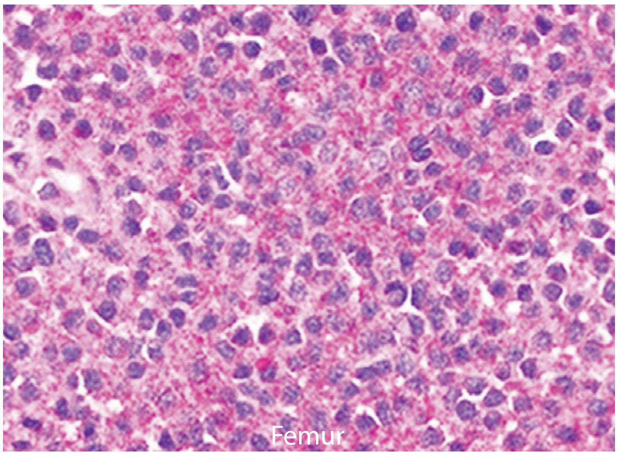


Fig. 48.22 Histopathology of Ewing's sarcoma (*Courtesy:* Dr Gitika Khanna)

- *Gross feature of specimen:*
  - Gray-white tumor
  - Expanded tumor mass
  - *Section shows:*
    - Severe involvement of medulla and cortex with perosteal elevation
    - Soft and friable necrotic area resembling pus
- *Histopathology of Ewing's sarcoma (Fig. 48.22)*:
  - Metaphyseal diaphyseal origin
  - Small round blue cells, (pseudorosettes formation—tumor cells arranged around capillaries)
  - Blue on hematoxylin and eosin staining
  - Glycogen positivity by periodic Schiff (PAS) and reticulin negative.
  - *Tumor containing round blue cell:* mnemonic—PEARL DOMS
    P—primitive neuroectodermal tumor
    E—Ewing sarcoma
    A—acute leukemia
    R—rhabdomyosarcoma
    L—lymphoma
    D—desmoplastic round cell tumor
    O—osteosarcoma
    M—mesenchymal chondrosarcoma
    S—small cell mesothelioma
- *Surgical procedure for Ewing's tumor:*
  - Wide resection of tumor with limb salvage procedure
  - Amputation of limb.

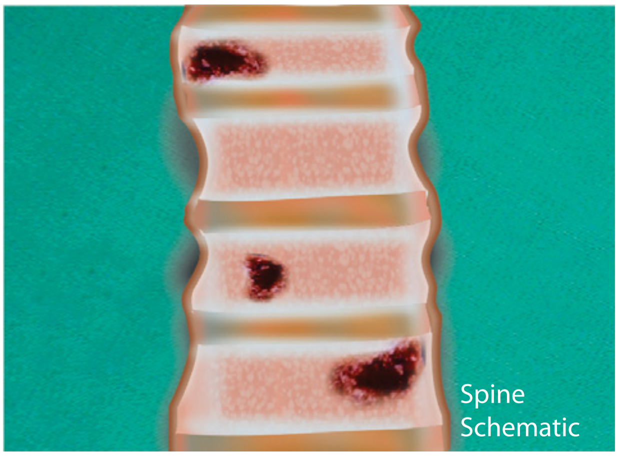


Fig. 48.23 Specimen of multiple myeloma spine

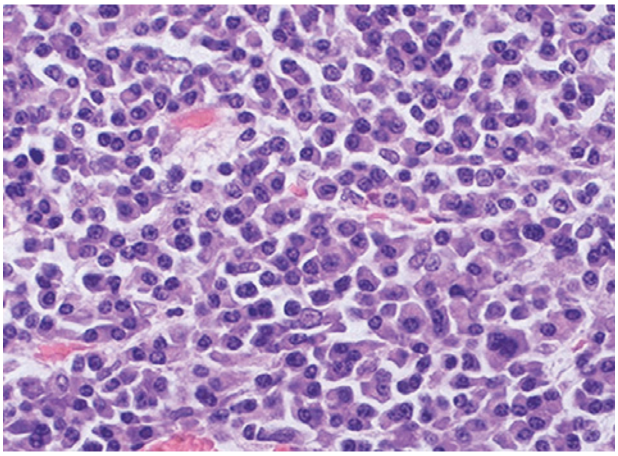


Fig. 48.24 Histopathology of multiple myeloma (*Courtesy:* Dr Gitika Khanna)

SPECIMEN OF MULTIPLE MYELOMA SPINE

- *Identification of specimen (Fig. 48.23):*
  - Myeloma spine—section
  - *Age group:* 6 to 7 decade
- *Bone involvement:* Axial skeleton and flat bone
- *Gross feature of specimen:*
  - Reddish grey tumor.
  - *Section shows:* Soft reddish material in the body with intact disc and normal vertebral height.
- *Histopathology of multiple myeloma (Fig. 48.24):*
  - Sheets of plasma cells.
  - Abundant cytoplasm with perinuclear Halo.
- *Surgical indication:* Prophylactic and definitive stabilization of bone and spine.

SECTION 6

Orthopedic Surgical Approaches

Upendra Kumar

Chapters

CHAPTER

49

Shoulder and Arm

SHOULDER: ANTERIOR APPROACH (DELTOPECTORAL APPROACH) (FIG. 49.1)

- How patient lies on OT table?
  Supine position with arm by the side of trunk.
- What is the line of incision?
  Straight line from tip of coracoid along the deltopectoral groove.

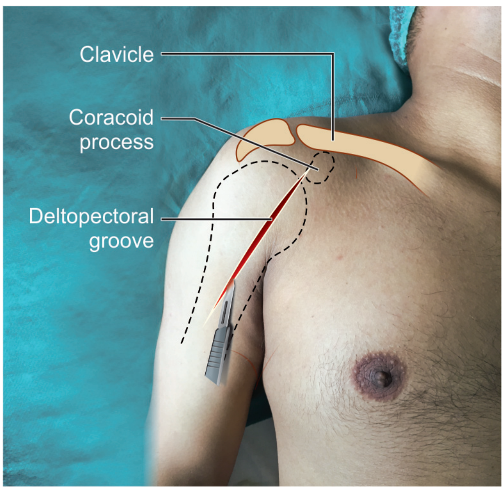


Fig. 49.1 Shoulder: Anterior approach (Deltopectoral approach)

- What dissection plane surgeon follows?
  Between anterior fibers of deltoid and pectoralis major.
- What are the structures at risk in this approach?
  - Cephalic vein
  - Musculocutaneous nerve
  - Axillary nerve
  - Anterior circumflex humeral artery.
- What are the common surgeries performed through this approach?
  - Biopsy and drainage of shoulder joint
  - Proximal humerus fracture fixation
  - Surgery for shoulder dislocation and instability
  - Shoulder arthroplasty.
- *Points of special interest:*
  - *Cephalic vein:* Identification point for deltopectoral groove.
  - *Biceps tendon:* Identification mark for medial (lesser tuberosity) and lateral structure (greater tuberosity) of fracture head of humerus.
  - *Rotator interval:* Rotator-interval is found between supraspinatus and subscapularis muscle. It contains superior glenohumeral and coraco-humeral ligament. Rotator-interval helps in reduction of posterior dislocation of shoulder.
  - *Coracoid osteotomy:* Used for **Latarjet** and **Bristow** operations.

ARM: ANTERIOR/ANTEROLATERAL APPROACH OF ARM (FIG. 49.2)

- What is position of patient on OT table?
  Supine position with arm by the side of trunk.
- What is the line of incision?
  Lateral border of biceps (Incision length depends upon site of surgery).
- What dissection plane surgeon follows?
  - *Proximal plane:* Between anterior fibers of deltoid and pectoralis major
  - *Distal plane:* Split the fibers of brachialis muscle.
- What are the structures at risk in this approach?
  - Cephalic vein
  - Axillary nerve
  - Anterior circumflex humeral vessels
  - Radial nerve in spiral groove
  - Musculocutaneous nerve.
- What are the common surgeries performed through this approach?
  - Humerus fracture fixation
  - Osteomyelitis of humerus
  - Tumor surgery.
- *Points of special interest:*
  - *Proximal extension:* Along deltopectoral groove, used for fracture upper 1/3rd humerus
  - *Distal extension:* Dissect between brachialis and brachioradialis, used for fracture distal 1/3rd humerus, radial nerve can also dissected through this plane.

ARM: POSTERIOR APPROACH OF ARM (FIG. 49.3)

- How patient lies on OT table?
  Lateral position in such a way that arm abducted and elbow supinated and flexed (arm rest is essential).
- What is the line of incision?
  In the line of angle of acromion of scapula to tip of olecranon process of ulna (length of incision depends upon site of surgery).

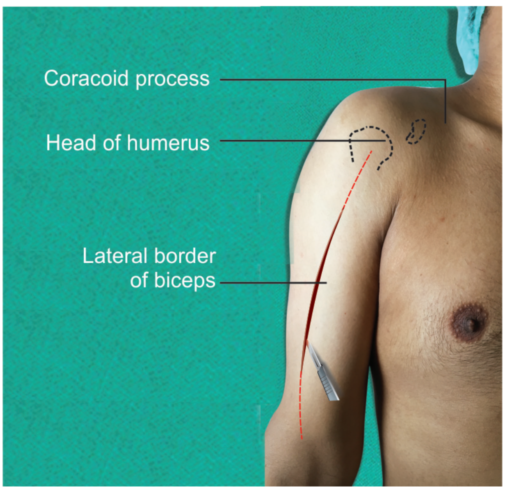


Fig. 49.2 Arm: Anterior/anterolateral approach of arm

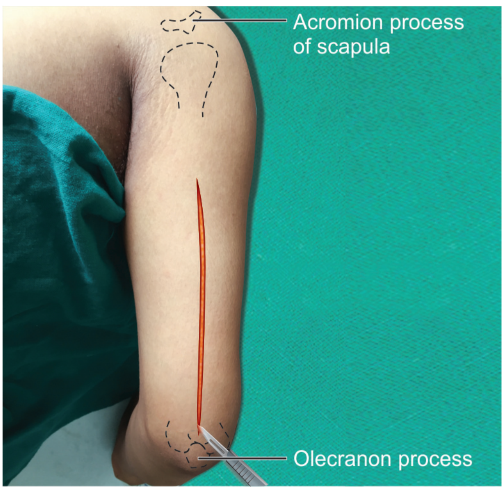


Fig. 49.3 Arm: Posterior approach of arm

- What dissection plane surgeon follows?
  - Superficial plane—in between long and lateral head of triceps.
  - Deep plane—split the medial head of triceps.
- What are the structures at risk in this approach?
  - Radial nerve
  - Profunda brachii artery; a major branch of radial artery.
- What are the common surgeries performed through this approach?
  - Fracture of shaft humerus in distal 2/3rds.
  - Radial nerve exploration.

CHAPTER

50

Distal Arm, Elbow and Proximal Forearm

ELBOW: POSTERIOR APPROACH OF ELBOW (FIG. 50.1)

- How patient lies on OT table?
  Lateral position in such a way that arm forwardly flexed and elbow supinated and flexed by keeping arm on arm rest.
- What is the line of incision?
  Start from midline of posterior aspect of arm →tip of olecranon process of ulna → extend to lateral side of olecranon process.
- What are the different (dissection) method to approach elbow?

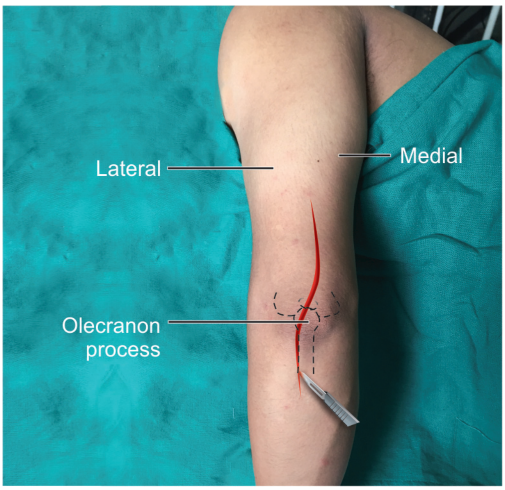


Fig. 50.1 Elbow: Posterior approach of elbow

  - Olecranon osteotomy method.
  - Triceps (midline) split method (**Campbell**).
  - Tounge-shaped triceps flap lifting and rest triceps splitting method (**Campbell**).
  - Bilateral columnar detachment method.
  - TRAP (triceps reflecting anconeus pedicle) method.
- What are the structures at risk in this approach?
  - Ulnar nerve.
  - Median nerve.
  - Radial nerve.
- What are the common surgeries performed through this approach?
  - Intercondylar fracture humerus fixation.
  - Elbow arthroplasty.
- *Point of special interest:*
  - Meticulous dissection of ulnar nerve.

ELBOW: LATERAL APPROACH (KOCHER'S APPROACH) (FIG. 50.2)

- How patient lies on OT table?
  Supine position with arm by the side of trunk, elbow flexed and pronated.
- What is the line of incision?
  J-shaped incision; start 5 cm proximal to elbow along lateral supracondylar ridge and continue down 5 cm distal to radial head and curve it to the posterior border of ulna.

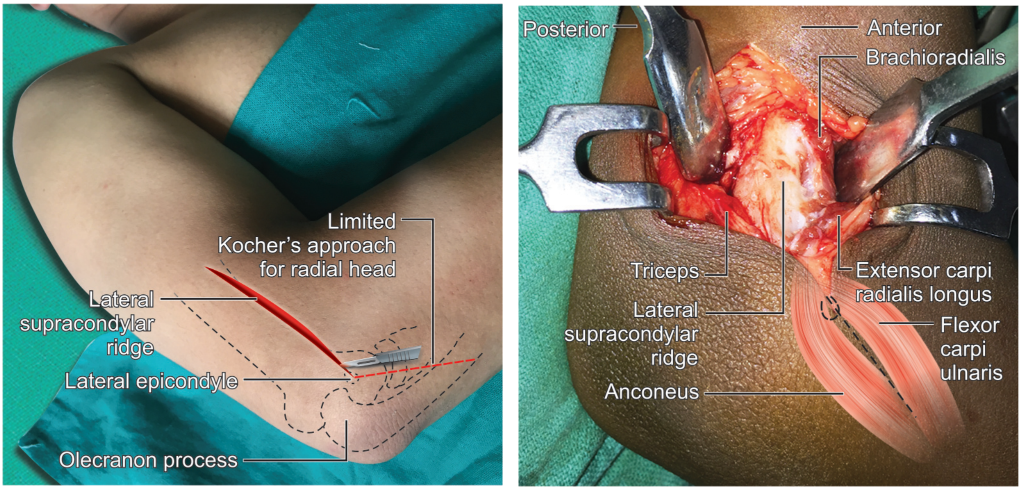


Fig. 50.2 Elbow: Lateral approach (Kocher's approach)

- What dissection plane surgeon follows?
  - *Proximally:* Between triceps and brachioradialis muscle.
  - *Distally:* Between anconeus and extensor carpi ulnaris muscle.
- What structure is at risk in this approach?
  Posterior interosseous nerve.
- What are the common surgeries performed through this approach?
  - Fixation of fracture lateral condyle, epicondyle and capitulum of humerus.
  - Fixation of fracture supracondylar humerus.
  - Procedures over radial head.
  - Soft tissue reconstruction around elbow.
- *Points of special interest:*
  - *Limited **Kocher's** approach:* Incision in straight line from tip of lateral epicondyle to 5 cm distal to tip of olecranon process of ulna and dissection plane is in between anconeus and extensor carpi ulnaris muscle. It access radial head directly but invites a serious complication in the form of lateral ligament complex injury that may lead to elbow instability. To prevent it, **Hotchkiss** advocated to access radial head directly through extensor digitorum communis.
  - In communited radial head fracture; excise the radial head and try to rearrange on OT table, so that radial head is fully formed otherwise there is a great chance of missing of fragments that needs further exploration.
  - *Modified **Kocher's** approach:* When the distal extension of "Limited Kocher's approach" is made up to the junction of upper third and middle third of ulna, it is called modified Kocher's approach. This approach also preserve the integrity of lateral ligament complex.
  - ***Boyd's** approach:* Start approx 2.5 cm proximal to elbow joint just lateral to triceps muscle and continue it along subcutaneous (posterior) border of ulna. This approach is used for reduction of Monteggia fracture dislocation with or without ulnar osteotomy.

ELBOW: ANTERIOR APPROACH (FIG. 50.3)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and supinated.
- What is the line of incision?
  Start from lateral border of biceps tendon → run along flexor crease → goes to medial border of brachioradialis.
- What dissection plane surgeon follow?

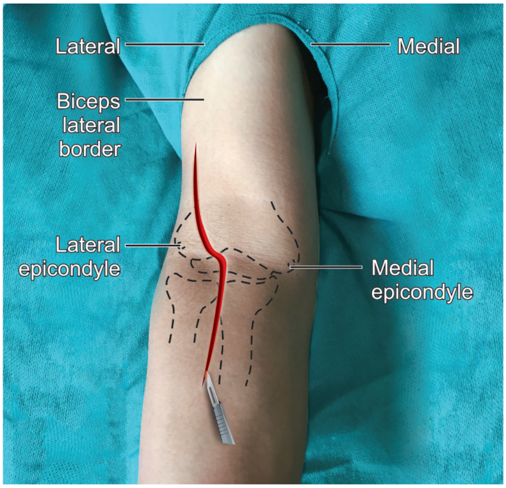


Fig. 50.3 Elbow: Anterior approach

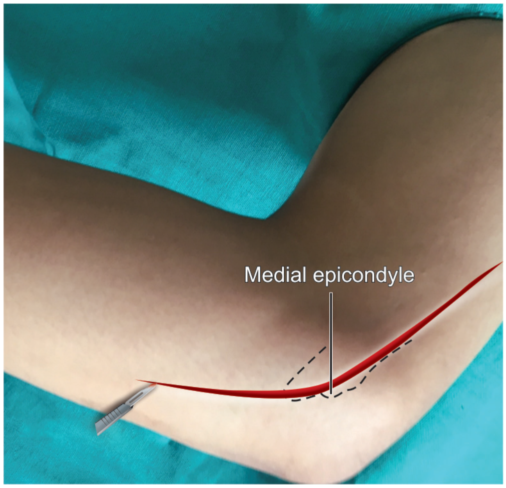


Fig. 50.4 Elbow: Medial approach

  - *Proximally:* Between brachialis and brachioradialis muscle.
  - *Distally:* Between brachioradialis and pronator teres muscle.
  - Use either proximal, distal or both dissection as per requirement.
- What the structures at risk in this approach?
  - Lateral cutaneous nerve of forearm.
  - Posterior interosseus nerve.
  - Recumbent branch of radial artery.
- What are the common surgeries performed through this approach?
  - Fixation of fracture capitellum.
  - Surgery for biceps avulsion from bicipital tuberosity.

ELBOW: MEDIAL APPROACH (FIG. 50.4)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and supinated.
- What is the line of incision?
  Start from medial supracondylar ridge—centering over medial epicondyle—run distally along medial border of forearm.
- What dissection plane surgeon follows?
  - Proximally → Between brachialis and triceps muscle.
  - Distally → Between brachialis and pronator teres muscle.
- What are the structures at risk in this approach?
  - Ulnar nerve.
  - Median nerve.
- What are the common surgeries performed through this approach?
  - Fixation of fracture medial condyle, epicondyle, coronoid process of ulna, and fracture trochlea of humerus.
  - Removal of loose bodies.
- *Points of special interest:*
  - Meticulous dissection of ulnar nerve.
  - Medial epicondylar osteotomy may be needed.

CHAPTER

51

Forearm, Wrist and Hand

FOREARM: ANTERIOR APPROACH TO RADIUS (HENRY'S APPROACH) (FIG. 51.1)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and supinated. one can also use side table.
- What is the line of incision?
  Along a line that join a point lateral to biceps tendon and radial styloid process.
- What dissection plane surgeon follows?

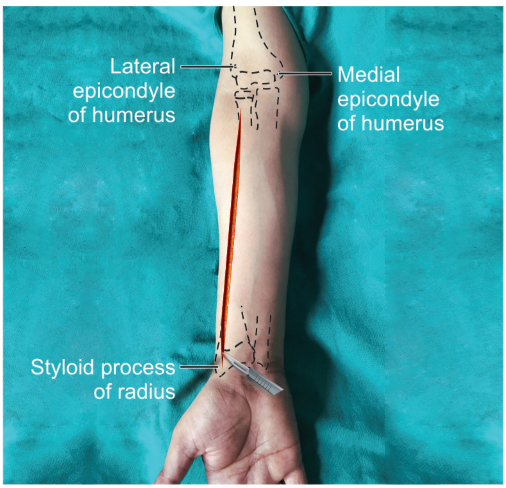


Fig. 51.1 Forearm: Anterior approach to radius (Henry's approach)

  Between brachioradialis and flexor carpi radialis muscle.
- What are the structures at risk in this approach?
  - Superficial radial nerve → laterally.
  - Radial artery with venae comitantes → medially.
  - Posterior interosseous nerve (proximally).
- What are the common surgeries performed through this approach?
  - Fixation of fracture radius
  - Osteomyelitis of radius
  - Tumor surgery.
- *Points of special interest:*
  - For proximal radius fracture—cut supinator insertion in full supination position.
  - For mid-shaft radius fracture—cut pronator teres insertion in full pronation position.
  - For distal radius fracture—cut pronator quadrates insertion in full supine position.

FOREARM: POSTERIOR APPROACH TO RADIUS (THOMPSON APPROACH) (FIG. 51.2)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and pronated. one can also use side table.

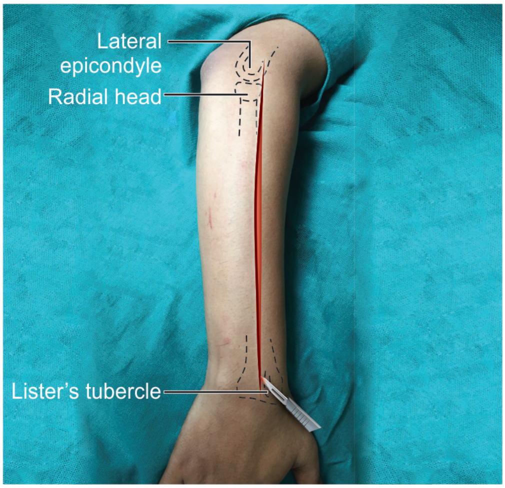


Fig. 51.2 Forearm: Posterior approach to radius (Thompson approach)

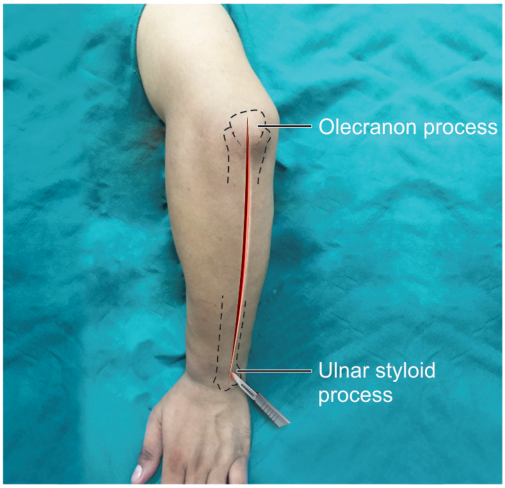


Fig. 51.3 Forearm: Posterior approach to ulna (Boyd's approach)

- What is the line of incision?
  Along a line that join lateral epicondyle of humerus to a point just medial to Lister's tubercle.
- What dissection plane surgeon uses?
  Between extensor carpi radialis brevis and extensor digitorum communis.
- What are the structures at risk in this approach?
  - Posterior interosseous nerve.
- What common surgeries performed through this approach?
  Various procedures on radius like fracture fixation, osteomyelitis or tumor treatment.
- *Points of special interest:*
  - For proximal fracture—dissect the posterior interosseous nerve by cutting oblique insertion of supinator muscle over radius.

FOREARM: POSTERIOR APPROACH TO ULNA (BOYD'S APPROACH) (FIG. 51.3)

- How patient lies on OT table?
  For middle 1/3rd or lower 1/3rd ulna; supine position and arm by the side of trunk with elbow flexed and supinated. One can also use side table.
  For upper 1/3rd ulna; lateral position and arm forwardly flexed with elbow flexed and supinated.
- What is the line of incision?
  Along subcutaneous border of ulna (length of incision depends upon site of fracture).
- What dissection plane surgeons follows?
  Between flexor carpi ulnaris and extensor carpi ulnaris muscle.
- What are the structures at risk in this approach?
  - Ulnar nerve.
  - Ulnar vessel.
- What are the common surgeries performed through this approach?
  - Ulnar fracture fixation
  - Osteomyelitis of ulna
  - Tumor surgery.

FOREARM AND WRIST: VOLAR APPROACH FOR DISTAL RADIUS AND WRIST (FIG. 51.4)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and supinated.

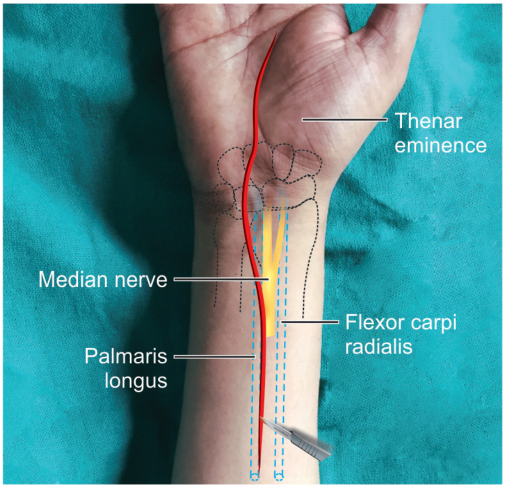


Fig. 51.4 Forearm and wrist: Volar approach for distal radius and wrist

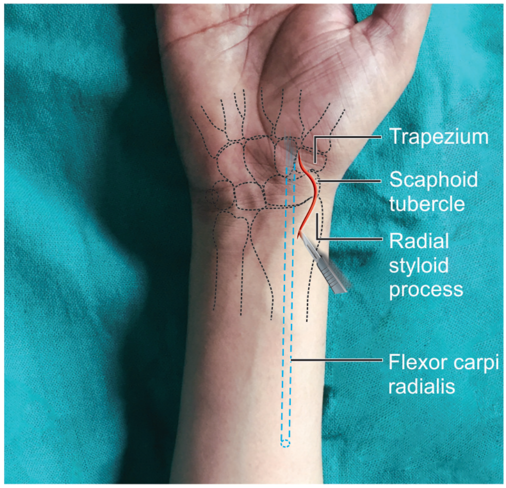


Fig. 51.5 Wrist joint: Volar approach for scaphoid

- What is the line of incision?
  Palpate the tendon of flexor carpi radialis and palmaris longus and incision run as follows: start from middle of flexor carpi radialis and palmaris longus tendon in distal forearm deviate ulnarward at wrist flexor crease and go to medial side of thenar prominence.
- What is dissection plane surgeon follows?
  - *Superficial plane:* Between flexor carpi radialis and palmaris longus.
  - *Deep plane:* Between flexor pollicis longus and flexor digitorum superficialis.
- What are the structures at risk in this approach?
  - Median nerve, palmar cutaneous branch of median nerve.
  - Radial artery.
- What are the common surgeries performed through this approach?
  - Fixation of fracture distal radius.
  - Median nerve exploration.
  - Release of flexor crease for carpel tunnel syndrome.
  - Synovectomy of wrist joint.

WRIST JOINT: VOLAR APPROACH FOR SCAPHOID (FIG. 51.5)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and supinated.
- What is the line of incision?
  A curve incision—centering over scaphoid tubercle, run proximally to radial styloid process and go distally towards trapezium bone.
- What dissection plane surgeon follows?
  Between radial artery and venae comitantes laterally and tendon of flexor carpi radialis medially.
- What are the structures at risk in approach?
  - Radial artery.
  - Palmar cutaneous branch of median nerve.
- What are the common surgeries performed through this approach?
  - Procedure over scaphoid (specially proximally 3rd)
  - Excision of radial styloid.

WRIST JOINT: DORSAL APPROACH FOR SCAPHOID (FIG. 51.6)

- How patient lies on OT table?
  Supine position with arm by the side of trunk with elbow extended and supinated.
- What is the line of incision?
  (S-shaped incision) centering over anatomical snuff box run proximally to radial styloid process and end distally at the base of 1st metacarpal bone.
- What dissection plane surgeon follows?
  Between extensor pollicis brevis (laterally) and extensor pollicis longus (medially).
- What are the structures at risk in this approach?
  - Radial artery.
  - Superficial branch of radial nerve.
  - Cephalic vein.
- What are the common surgeries performed through this approach?
  - Surgery over scaphoid.
  - Excision of radial styloid process.

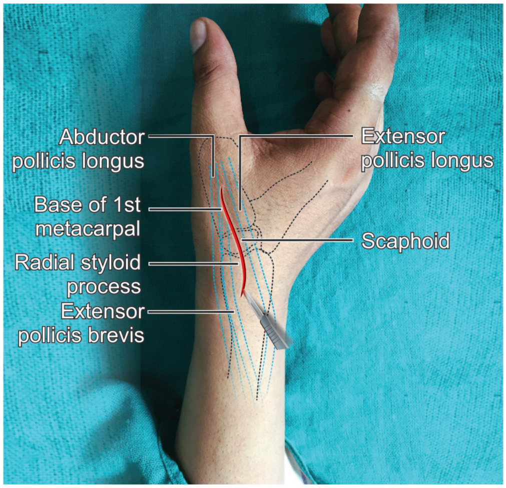


Fig. 51.6 Wrist joint: Dorsal approach for scaphoid

CHAPTER

52

Spine

CERVICAL SPINE: ANTERIOR APPROACH TO CERVICAL SPINE (SOUTHWICK AND ROBINSON APPROACH) (FIG. 52.1)

- How patient lies on OT table?
  Supine position with head in right/left lateral position.
- What is the line of incision?
  - Transverse incision → at appropriate vertebral pathology.

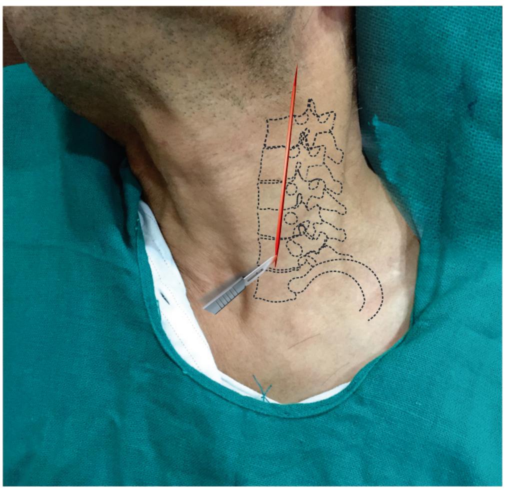


Fig. 52.1 Cervical spine: Anterior approach to cervical spine (Southwick and Robinson approach)

Bony landmarks:
Hard palate—arch of atlas
Lower border of mandible—C2-C3
Hyoid bone—C3
Thyroid cartilage—C4-C5
Cricoids cartilage—C6
Carotid tubercle—C6

  - Vertically oblique → anterior to sternocleidomastoid prominence.
- What are the steps of dissection?
  - Split platysma.
  - Dissect between sternocleidomastoid muscle and deep cervical fascia over strap muscles.
  - Palpate carotid artery and make a plane between carotid sheath and midline structures like esophagus and trachea.
  - Blunt dissection to reach prevertebral fascia.
  - Sharp dissection between longus (colli and capitis) muscle of either side to reach the body of vertebrae.
- What are the structures at risk in this approach?
  - Recurrent laryngeal nerve.
  - Contents of carotid sheath—common carotid artery, internal jugular vein and vagus nerve.
  - Vertebral artery.
  - Trachea and esophagus.

- What are the common surgeries performed through this approach?
  - Spinal fracture fixation.
  - Vertebral disc surgery.
  - Vertebral interbody fusion.
  - Spinal osteomyelitis.
  - Spine tumors.
- *Points of special interest:*
  - *Preferred position of patient:* Right lateral and surgery over left side of neck. Why so?
    - Course of left recurrent laryngeal nerve is predictable.
    - Right recurrent laryngeal nerve is fixed to trachea.

DORSAL SPINE: TRANSTHORACIC APPROACH (FIG. 52.2)

- How patient lies on OT table?
  Right lateral/left lateral position.
- What is the line of incision?
  Incision line run as follows: Centering over 2 finger breath below inferior angle of scapula and extend forward towards inframammary crease and extend backward and upward towards thoracic spine.

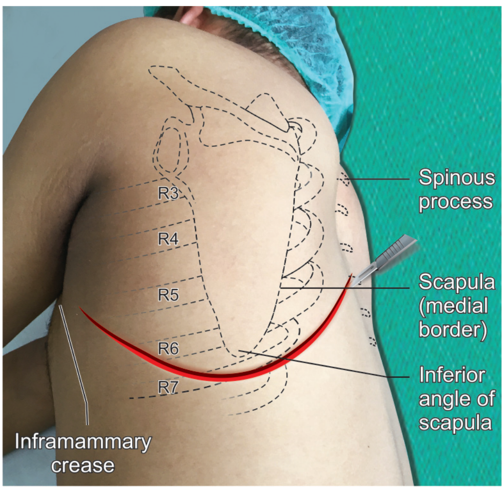


Fig. 52.2 Dorsal spine: Transthoracic approach

- What are the steps of dissection?
  - *Muscles are cut as follows:*
    - Serratus-anterior muscle anteriorly
    - Latissimus dorsi in middle
    - Trapezius muscle posteriorly.
  - Assess through 5th intercostals space to approach up to T8-9 vertebrae but use 6th intercostals space for lower dorsal vertebrae.
  - Approach superior border of lower rib of the particular space → rib rasping done → do rib cutting → parietal pleura exposed.
- What are the structures at risk in this approach?
  - Intercostal vessels.
  - Lung.
- What are the common surgeries performed through this approach?
  - Surgery over thoracic vertebral bodies for Potts' spine.
  - Vertebral interbody fusion.
  - Anterior cord decompression.
  - Spinal osteotomy.
  - Spinal biopsy.
- *Points of special interest:*
  - *Preferred position of patient:* Right lateral so that angle between body and table is 45° and surgery over left side of chest. Why so?
    - Aorta is visible and less chances of injury.
    - If injury to aorta occur; it is easier to repair.

DORSAL SPINE: COSTO-TRANSVERSECTOMY (FIG. 52.3)

- How patient lies on OT table?
  Right/left lateral position.
- What is the line of incision?
  (***Capener's*** *incision*): A "C" shaped incision 8–10 cm lateral to affected spinous process—extend 5 cm above and below respectively from concerned spinous process.
- What are the steps of dissection?
  - Cut through trapezius; in the line of muscle fibers.
  - Rib resection → 6–8 cm from midline.

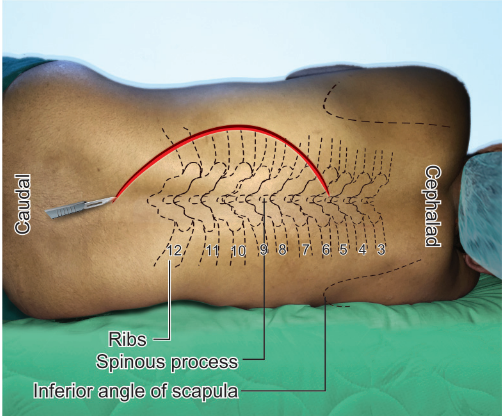


Fig. 52.3 Dorsal spine: Costotransversectomy

- Divide transverse process at junction of lamina with pedicle.
- Enter the retropleural space by digital dissection to reach anterolateral part of body.
- Intercostal neurovascular bundle is a guide for intervertebral foramina and assess the posterolateral part of body.

- What are the structures at risk in this approach?
  - Intercostal vessels
  - Pleura of lung.
- What are the common surgeries performed through this approach?
  - Vertebral abscess drainage
  - Vertebral body resection (partial)
  - Vertebral body biopsy
  - Anterolateral decompression of spinal canal (Pott's spine).
- *Points of special interest:*
  - *Preferred position of patient:* Right lateral and surgery over left side of chest. Why so?
    - Aorta is visible and less chances of injury.
    - If injury to aorta occur; it is easier to repair.
    - Left lung fall anteriorly and it decreases the chances of lung injury.

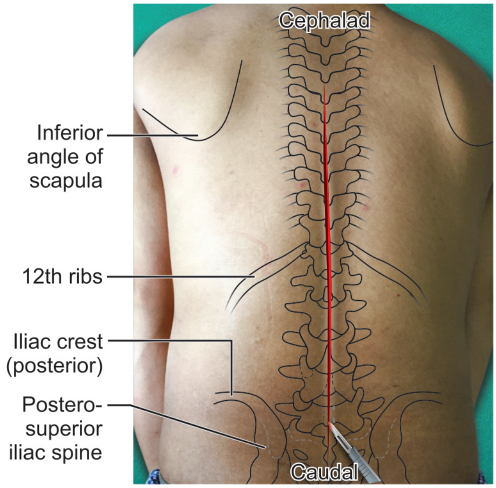


Fig. 52.4A Dorsolumbar spine: Interlaminar approach of spine

DORSOLUMBAR SPINE: INTERLAMINAR APPROACH OF SPINE (FIG. 52.4A)

- How patient lies on OT table?
  Prone position or right/left lateral.
- What is the line of incision?
  Midline incision in the line of spinous process of C7 vertebrae and natal cleft according to site of affected vertebrae.
- What are the steps of dissection?
  - Incision over thoracolumbar fascia in midline.
  - Cutting of paraspinal muscle by the side of spinous process.
  - Retract the paraspinal muscle from spinous process to edge of lamina.
  - Dissection for articular facet joint and transverse process.
- What are the structures at risk?
  - Dorsal primary rami
  - Segmental vessels.
- What are common surgeries performed through this approach?
  - Stabilization of fracture vertebrae.
  - Posterior spinal fusion.

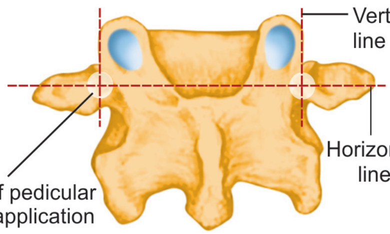


Fig. 52.4B Entry point for lumbar pedicular screw

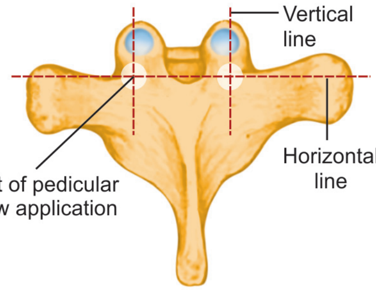


Fig. 52.4C Entry point for thoracic pedicular screw

  - Scoliosis surgery.
  - Tumor removal.
- *Points of special interest:*
  - *Entry point for lumbar pedicular screw (Fig. 52.4B):* The bisector of two imaginary lines, one (horizontal) in the plane of upper 1/3rd of transverse process and another (vertical) just lateral to facet joint; direction is caudal and medial (0-10° at L1 vertebrae and 20-30°at L5 vertebrae).
  - *Entry point for thoracic pedicular screw (Fig. 52.4C):*
    - The bisector of two imaginary lines, one (horizontal) in the plane of base of superior articular facet and another (vertical) at the junction of lateral 1/3rd and medial 2/3rds of same facet. Direction is caudal and medial.
    - *Narrower pedicles:* Narrowest pedicles are found in thoracic T4-T5-T6 vertebrae and technique for pedicular screw insertion in these vertebrae is IN-OUT (lateral pedicle wall)—IN (body). This technique decrease the risk of medial penetration and increase the hold of screw in bone.(***Belmonte et al.***).

CHAPTER

53

Pelvis, Hip and Thigh

PELVIS: ANTERIOR APPROACH (ILIOINGUINAL APPROACH) (FIG. 53.1)

- How patient lies on OT table?
  Supine position with slight flexion on hip by keeping bolster below the knee.
- What is the line of incision?
  A curved incision which begin 5 cm above the anterior superior iliac spine (ASIS), parallel to inguinal ligament and end 1 cm above public tubercle up to midline.

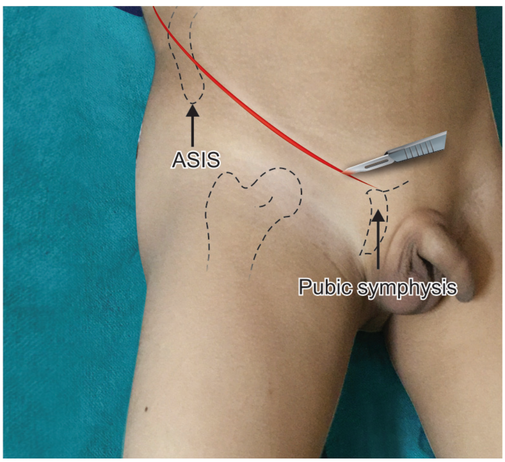


Fig 53.1 Pelvis: anterior approach (ilioinguinal approach)
Abbreviation: ASIS, anterior superior iliac spine

- What dissection plane surgeon follows?
  - *First layer*: External oblique muscle and aponeurosis and superficial inguinal ring.
  - *Second layer*: Internal oblique and transverses abdominis muscle with conjoint tendon → fascia transversalis and deep inguinal ring.
  - *Third layer*: Extra-peritoneal fat.
- What are the structures at risk in this approach?
  - Lateral cutaneous nerve of thigh.
  - Femoral nerve.
  - Femoral vessels.
  - Inferior epigastric vessels.
  - Spermatic cord and bladder.
- What are the common surgeries performed through this approach?
  - Surgeries over anterior column of acetabulum.
  - To asses anteromedial aspect of acetabulum.
- *Points of special interest:*
  - *Bundles:*
    - *Lateral bundle:* Iliopsoas muscle and femoral nerve.
    - *Middle bundle:* Femoral vessels.
    - *Medial bundle:* Spermatic cord.
  - *Pockets/windows:*
    - Lateral → lateral to ilipsoas muscle; acess to ilium bone.

- Middle → between iliopsoas and femoral vessels; access to quadri lateral plate.
- Medial → medial to femoral vessels; access to superior pubic rami and pubic symphysis.

PELVIS: POSTERIOR APPROACH (KOCHER-LANGENBECK)

- How patient lies on OT table?
  Right/left lateral or prone position.
- What is the line of incision?
  A 10–15 cm curved incision, centering over posterior aspect of greater trochanter; extend proximally in direction of posterior-superior iliac spine (PSIS) and distally in direction of shaft of femur.
- What dissection plane surgeons follows?
  Split gluteus-maximus muscle at junction of upper 1/3rd and lower 2/3rd of its girth.
- What are the structures at risk in this approach?
  - Superior and interior gluteal vessels.
  - Superior gluteal nerve.
  - Sciatic nerve.
- What are the common surgeries performed through this approach?
  - Fracture of posterior wall of acetabulum.
  - Fracture of posterior column of acetabulum.
  - Posterior wall and column fracture.
  - Transverse fracture.
- *Points of special interest:*
  - Flexion attitude of knee—to prevent stretch over sciatic nerve.
  - Trochanteric flip osteotomy—for more exposure of acetabular wall and column.

HIP: ANTERIOR APPROACH (SMITH-PETERSON APPROACH) (FIG. 53.2)

- How patient lies on OT table?
  Supine position
- What is the line of incision?

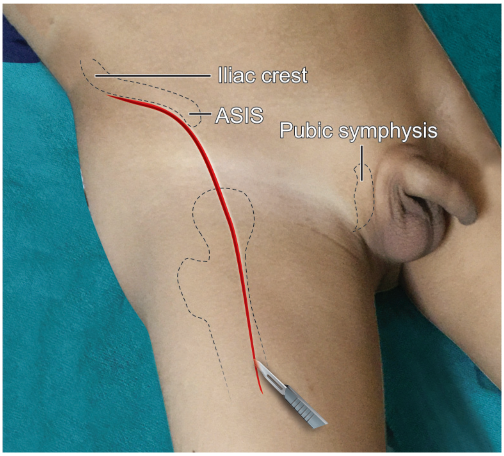


Fig. 53.2 Hip: Anterior approach (Smith-Peterson approach)

Start from middle of iliac crest, centering over ASIS and extend longitudinally along thigh in line of lateral border of patella.

- What dissection plane surgeons follows?
  - Superficial plane—between tensor fascia femoris and Sartorius muscle.
  - Deep plane—between gluteus medius and rectus femoris muscle
- What are the structures at risk in this approach?
  - Femoral nerve.
  - Lateral cutaneous nerve of thigh.
  - Ascending branch of lateral circumflex femoral artery.
- What common surgeries performed through this approach?
  - Drainage of septic arthritis of hip in children.
  - Synovial biopsy.
  - Tumor surgery
  - Intra-articular arthrodesis
  - Developmental dysplasia of hip.
  - Open reduction of anterior dislocation of hip.
- *Points of special interest:*
  - **Somerville** approach or Bikni incision: Incision extends from middle of iliac crest to middle of inguinal point.

HIP: POSTERIOR APPROACH (MOORE'S OR SOUTHERN APPROACH) (FIG. 53.3)

- How patient lies on OT table?
  Right or left lateral position
- What is the line of incision?
  A 10–15 cm curved incision, centering over posterior aspect of greater trochanter; extend proximally in direction of posterior-superior iliac spine (PSIS) and distally in direction of shaft of femur.
- What dissection plane surgeons follows?
  Split gluteus maximus muscle at junction of upper 1/3rd and lower 2/3rd of its girth.
- What are the structures at risk in this approach?
  - Sciatic nerve.
  - Inferior gluteal artery.
  - A branch of lateral circumflex femoral artery under quadratus femoris muscle.
- What are the common surgeries performed through this approach?
  - Hip arthroplasty (total, hemi and excision type).
  - Open reduction of posterior dislocation of hip.
- *Points of special interest:*
  - *Short external rotators: From above to below:*
    - Piriformis
    - Superior gemelli
    - Obturator internus
    - Inferior gemelli
    - Obturator externus
    - Quadratus femoris.

HIP: LATERAL APPROACH (HARDINGE APPROACH) (FIG. 53.4)

- How patient lies on OT table?
  Right/left lateral position
- What is the line of incision?
  Lazy J shape incision centering over the greater trochanter of femur.
- What dissection plane surgeon follows?
  Between tensor fascia femoris and gluteus maximus muscle.
  For better exposure for hip joint use:
  - Trochanteric flip osteotomy
  - Elevate gluteus medius and vastus lateralis muscle along with its periosteal sleeve
- What are the structures at risk in this approach?
  - Superior gluteal nerve.
  - Femoral nerve and vessels.
  - Transverse branch of lateral of circumflex femoral artery.

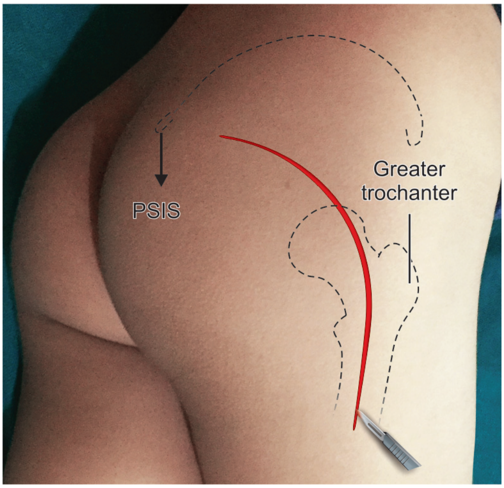


Fig. 53.3 Hip: Posterior approach (Moore's or Southern approach)

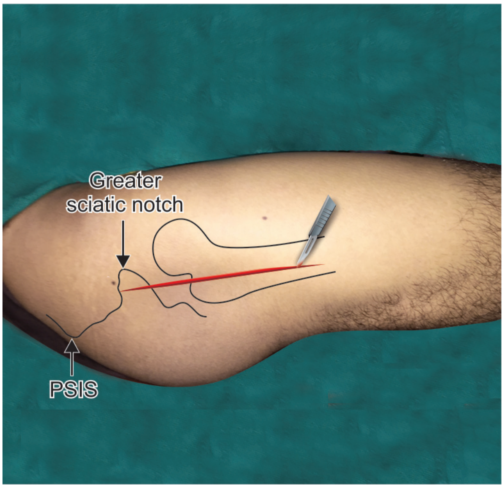


Fig. 53.4 Hip: Lateral approach (Hardinge approach)

- Which surgery is commonly performed through this approach?
  Hip arthroplasty.
- *Points of special interest:*
  – *Other approaches of hip:*
    - *Anterolateral approach (**Watson-Jone's** approach):* Dissection plane lies between tensor fascia femoris and gluteus medius muscle. Used for hip arthroplasty, synovial biopsy and sometime fracture neck fixation.
    - *Posterolateral approach (**Gibson's** approach):* Dissection plane lies between gluteus medius and gluteus maximus muscle. Used mainly for hip arthroplasty.
    - *Medial approach:*
      - ***Ludloff's** approach:* Dissection plane lies between pectineus and adductor longus and brevis.
      - Modified medial approach (**Hoppenfeld and Deboer**): Here superficial dissection plane lies between adductor longus and gracilis and deep plane lies between adductor brevis and adductor magnus.
      - Used for obturator neurectomy, iliopsoas release and rarely for developmental dislocation (dysplasia) of the hip (DDH) surgery.

THIGH: LATERAL APPROACH (FIG. 53.5)

- How patient lies on OT table?
  Right/left lateral position.

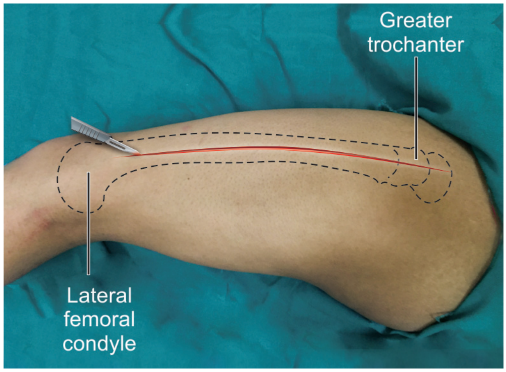


Fig. 53.5 Thigh: Lateral approach

- What is the line of incision?
  Along a line connecting greater trochanter to lateral femoral condyle (length of incision depends upon site of surgery).
- What dissection plane surgeon follows?
  Split iliotibial band, vastus lateralis and vastus intermedius muscle.
- What are the structures at risk in this approach?
  Perforating branches of profunda femoris artery a main branch of femoral artery.
- What are the surgeries commonly performed through this approach?
  – Fracture fixation of femur shaft and subtrochanteric region.
  – Osteomyelitis of femur.
  – Tumor surgery.
- *Points of special interest:*
  – In case of dealing with trochanteric region: two options
    - Vastus lateralis split approach
    - Vastus lateralis lift from its proximal origin approach

CHAPTER

54

Distal Thigh, Knee, and Proximal Leg

DISTAL FEMUR: LATERAL APPROACH (FIG. 54.1)

- How patient lies on OT table?
  Supine position.
- What is the line of incision?
  A long curved incision centering over middle of lateral condyle directed towards **Gerdy's** tubercle of tibia.
- What dissection plane surgeon follows?
  Between iliotibial band and vastus lateralis muscle.
- Which structures is at risk in this approach?
  Lateral superior genicular artery.

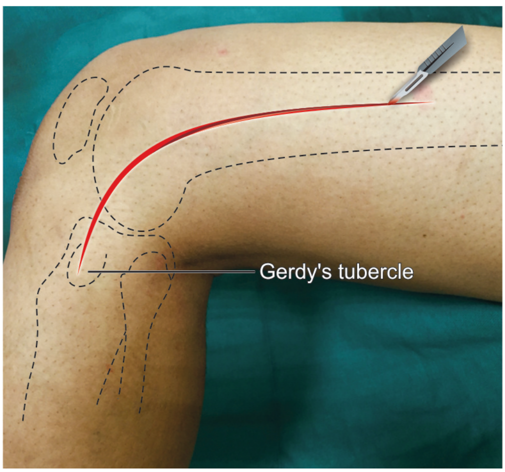


Fig. 54.1 Distal femur: Lateral approach

- What are the common surgeries performed through this approach?
  - Fixation of distal femur fracture (condylar, intra-articular, Hoffa's fractures).
  - Osteomyelitis of femur and septic arthritis of knee.
  - Biopsy and tumor resection.
- *Points of special interest:*
  - Posterolateral approach → Here dissection plane lies between iliotibial band and biceps femoris muscle.
  - Anterolateral approach **(Thompson)** → here dissection plane lies between rectus femoris and vastus lateralis muscle. This approach is used for Thompson procedure for quadriceps contracture.

DISTAL FEMUR: MEDIAL OR ANTEROMEDIAL APPROACH (FIG. 54.2)

- How patient lies on OT table?
  Supine position.
- What is the line of incision?
  A longitudinal incision; centering in between the bulk of rectus femoris and vastus medialis muscle.
- What dissection plane surgeon follows?
  Between rectus femoris and vastus medialis muscle. Split vastus intermedius.

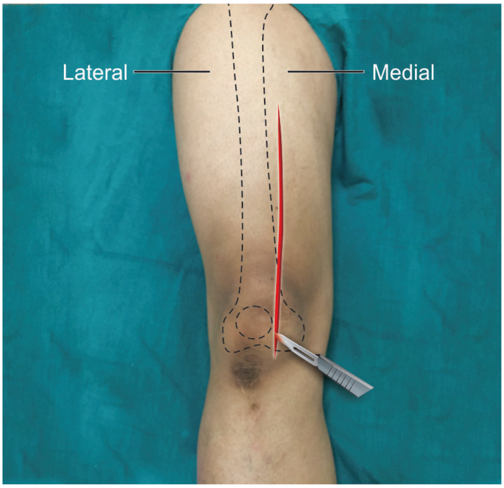


Fig. 54.2 Distal femur: Medial or anteromedial approach

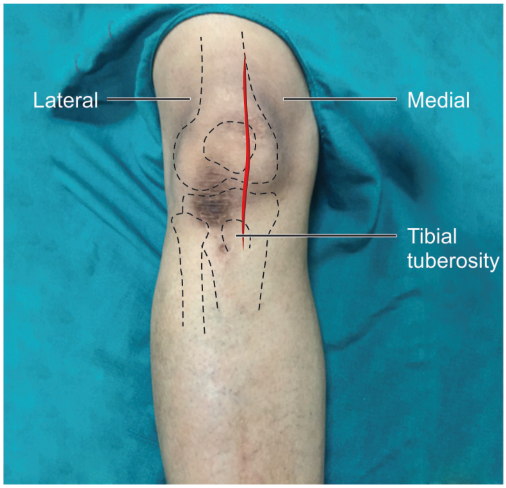


Fig. 54.3 Knee: Anterior approach (Medial parapatellar approach)

- What are the structures at risk in this approach?
  - Medial superior genicular artery.
  - Vastus medialis obliquus.
- What are the common surgeries performed through this approach?
  - Fixation of fracture medial condyle of femur.
  - Tumor surgery.
  - Osteomyelitis of femur.

KNEE: ANTERIOR APPROACH (MEDIAL PARAPATELLAR APPROACH) (FIG. 54.3)

- How patient lies on OT table?
  Supine position.
- What is the line of incision?
  A longitudinal straight midline incision; start 5–6 cm above from patella and extends up to tibial tuberosity.
- What dissection plane surgeon follows?
  - Proximally → rectus femoris and vastus medialis.
  - Distally → medial patellar retinaculum.
- What are the structures at risk in this approach?
  - Infrapatellar branch of saphenous nerve.
  - Ligamentum patellae.
- Surgeries performed through this approach?
  - Total knee arthroplasty.
  - Open ligament reconstruction.
  - Knee arthrotomy.
  - Open synovectomy.
  - Surgery over osteochondral defect.
  - Loose body removal.
  - Patellectomy.
- *Points of special interest:*
  - *Subvastus approach for total knee replacement (TKR):* Dissect inferior border of vastus medialis from intermuscular septum and periosteum of patella.
  - *Anterolateral approach for TKR:* Dissect lateral patellar retinaculum and capsule and dislocate patella medially.

KNEE: POSTERIOR APPROACH (FIG. 54.4)

- How patient lies on OT table?
  - Prone position
  - Lateral position with affected knee below.

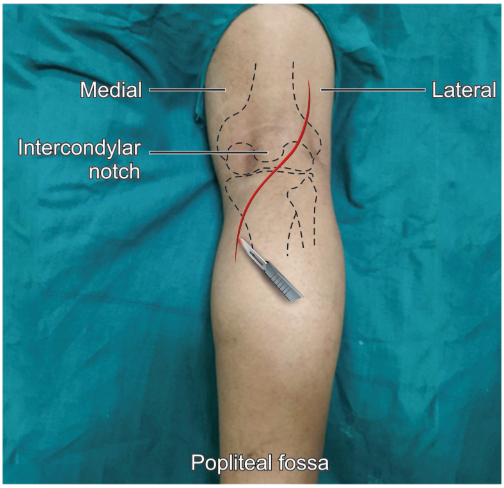


Fig. 54.4 Knee: Posterior approach

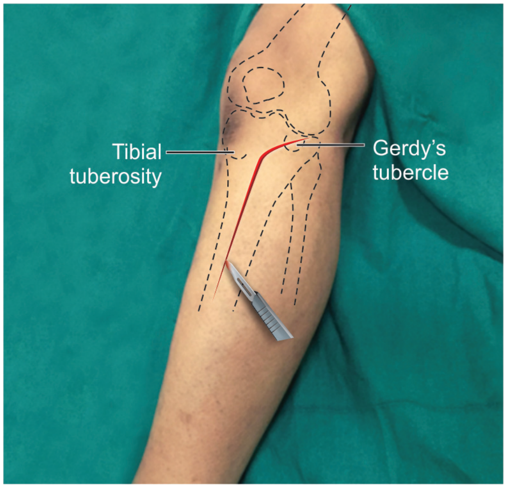


Fig. 54.5 Proximal tibia: Anterolateral approach

- What is the line of incision?
  A Lazy 's' curve; start from biceps femoris laterally—run obliquely in popliteal fossa and end over medial head of gastrocnemius medially.
- What dissection plane surgeon follows?
  Incise popliteal fascia just medial to small saphenous vein.
- What are the structures at risk in this approach?
  - Popliteal vessels.
  - Small saphenous vein.
  - Tibial nerve.
  - Common peroneal nerve.
- What are the common surgeries performed through this approach?
  - Excision of Baker's cyst and other popliteal cysts.
  - Fixation of avulsion fracture of posterior cruciate ligament.
  - Lengthening of hamstring muscles.

PROXIMAL TIBIA: ANTERO-LATERAL APPROACH (FIG. 54.5)

- How patient lies on OT table?
  Supine position.
- What is the line of incision?
  Start proximally from **Gerdy's** tubercle run to the tibia tuberosity and extend distally along shin of tibia (1 cm lateral).
- What dissection plane surgeon follows?
  Make incision through proximal and medial origin of tibialis anterior.
- What are the structures at risk in this approach?
  - Lateral meniscus.
  - Superficial branch of peroneal nerve.
- What are the surgeries performed through this approach?
  - Fixation of lateral tibia plateau fractures.
  - Osteomyelitis tibia.
  - Tumor surgery.
  - High tibial osteotomy.

PROXIMAL TIBIA: POSTERO-MEDIAL APPROACH (FIG. 54.6)

- How patient lies on OT table?
  Supine position with slightly flexed knee.
- What is the line of incision?
  A longitudinal incision lying over postero-medial border of proximal tibia.
- What dissection plane surgeon follows?
  Between posteromedial border of tibia (bone) and medial head of gastrocnemius muscle.

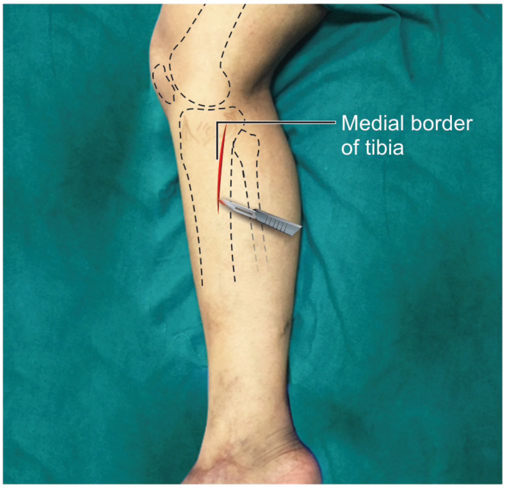


Fig. 54.6 Proximal tibia: Posteromedial approach

- What are the structures at risk in this approach?
  Saphenous nerve and vein.
- What are the common surgeries performed through this approach?
  - Fixation of posteromedial tibial plateau fractures.
  - Tumor surgery.

CHAPTER

55

Leg, Ankle and Foot

LEG: ANTERIOR OR ANTROLATERAL APPROACH (FIG. 55.1)

- In what position does the patient lie on OT table?
  Supine position
- What is the line of incision?
  A longitudinal incision 1 cm lateral to anterior border of tibia.
- What dissection plane does the surgeon follow?
  Reflect tibialis anterior from lateral surface of tibia.

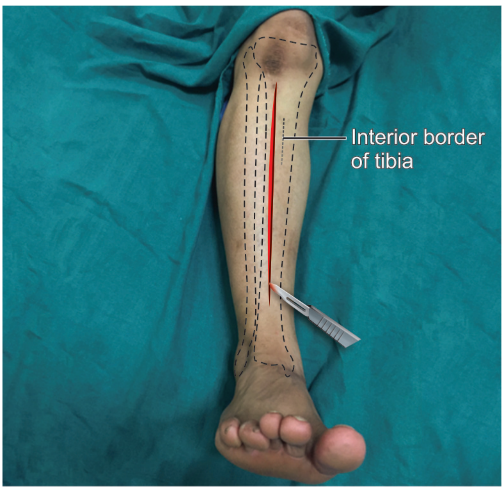


Fig. 55.1 Leg: anterior or antrolateral approach

- What structures is at risk in this approach?
  Not exactly but long saphenous vein is vulnerable if too medially.
- What are the common surgeries performed through this approach?
  - Fixation of fracture shaft of tibia (plating)
  - Osteomyelitis of tibia
  - Tumor surgery.

LEG: POSTEROLATERAL APPROACH (HENRY) (FIG. 55.2)

- In what position does the patient lie on OT table?
  - Supine position, keep a bolster underneath the buttock to maintain the leg in internal rotation attitude
- What is the line of incision?
  - A longitudinal incision along the posterior border of fibula in the line of posterior aspect of head of fibula and lateral malleoli.
- What dissection plane does the surgeon follow?
  - In between peroneus muscle (longus) and soleus.
- What structure is at risk in this approach?
  - Common peroneal nerve
  - Short saphenous vein
- What are the common surgeries performed through this approach?
  - Fixation of fracture shaft of fibula (plating)

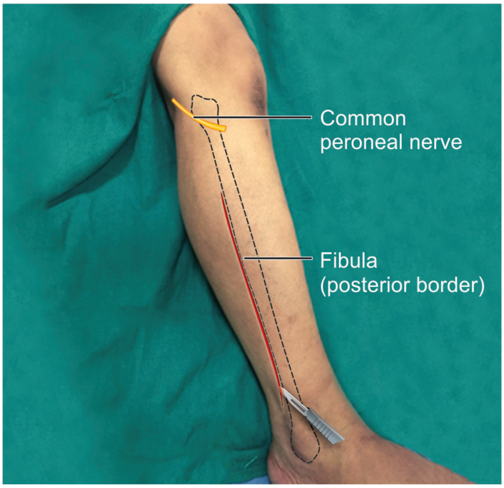


Fig. 55.2 Leg: posterolateral approach (Henry)

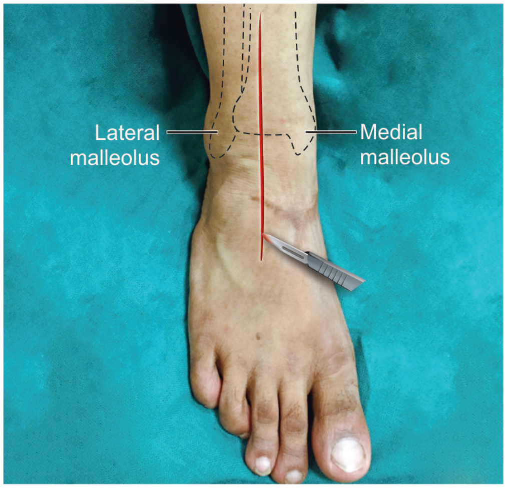


Fig. 55.3 Ankle: anterior approach

- Osteomyelitis of fibula
- Tumor surgery
- Fibulectomy for disease eradication or for bone graft.

- *Point of special interest:*
  - Dissect the common peroneal nerve while working on proximal fibula.

ANKLE: ANTERIOR APPROACH (FIG. 55.3)

- In what position does the patient lie on OT table?
  Supine position
- What is the line of incision?
  A straight longitudinal incision in front of ankle between two malleoli.
- What dissection plane does the surgeon follow?
  Between extensor hallucis longus and extensor digitorum longus.
- What are the structures at risk in this approach?
  - Superficial peroneal nerve (cutaneous branch)
  - Deep peroneal nerve
  - Anterior tibia artery.
- What are the common surgeries performed through this approach?
  - Tibial pilon fracture fixation.

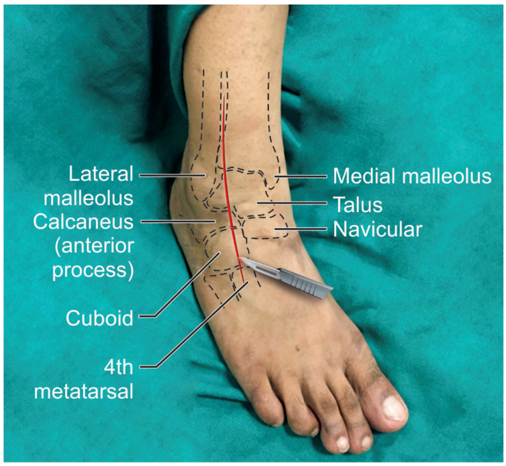


Fig. 55.4 Ankle: anterolateral approach

  - Arthrotomy of ankle.
  - Removal of loose body.

ANKLE: ANTEROLATERAL APPROACH (FIG. 55.4)

- In what position does the patient lie on OT table?
  Supine position
- What is the line of incision?
  A curved incision on anterolateral aspect of ankle. Begin 5 cm proximal to ankle joint,

2 cm anterior to anterior border of fibula and continue in direction of 4th ray.

- What dissection plane does the surgeon follow?
  - Between extensor digitorum longus and peroneus tertius to expose tibial plafond.
  - Between extensors (peroneus tertius) and peronei (peroneus longus and brevis) to expose the lower fibula, ankle joint and subtalar joint.
- What are the structures at risk in this approach?
  - Deep peroneal nerve.
  - Anterior tibial artery.
- What are the common surgeries performed through this approach?
  - Fixation of intra-articular distal tibial fracture.
  - Ankle fusion sometimes for triple arthrodesis and pantalar arthrodesis.

TALUS: MEDIAL APPROACH (FIG. 55.5)

- In what position does the patient lie on OT table?
  Supine position with slight flexion at knee.
- What dissection plane does the surgeon follow?
  Draw a curved incision centering over medial malleolus.

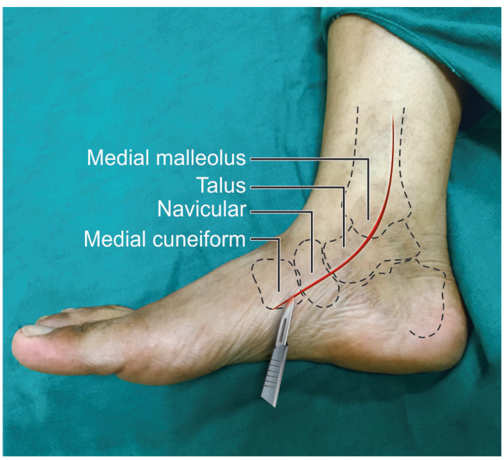
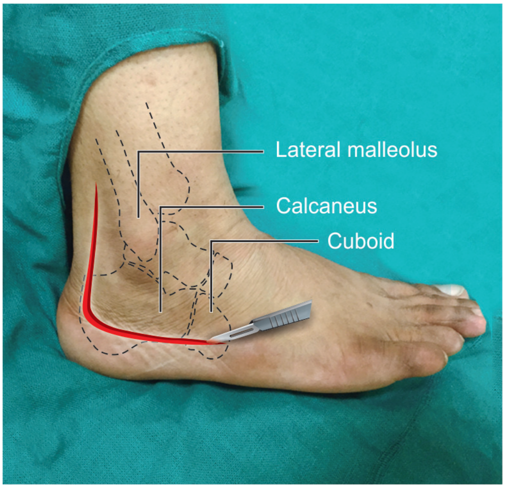


Fig. 55.5 Talus: medial approach

- What are the steps for dissection?
  - Incise flexor retinaculum just over tibialis posterior.
  - Do medial malleolar osteotomy to expose talus properly.
- What are the structures at risk in this approach?
  - Saphenous nerve
  - Great saphenous vein
  - Tendon of tibialis posterior.
- What are the common surgeries performed through this approach?
  - Fracture fixation of talus
  - Ankle arthrodesis.
- *Points of special interest:*
- Anteromedial incision over dorsum of mid-foot (talo-navicular joint) is also used for talar neck fracture.

CALCANEUM: LATERAL APPROACH (FIG. 55.6)

- In what position does the patient lie on OT table?
  Right/left lateral position with slight flexion of knee with affected foot up.
  Fasten a pillow over caudal end of OT table and keep foot over it.
- What is the line of incision?
  An "L" shaped incision where vertical arm of L lies between posterior aspect of fibula and lateral aspect of Achillies tendon and horizontal limb run in the direction of base of 5th metatarsal bone.
- What are the main steps of dissection?
  - Elevate thick flap (Skin to periosteum).
  - Insert three K-wire 2–2.5 mm each as:
    - Tip of lateral malleoli
    - Head of talus
    - Proximal cuboid.
  - Make a window over lateral wall of calcaneus—it makes the depressed posterior facet visible.
  - Apply a 3 mm K-wire or steinmann pin in tuberosity to elevate depressed posterior facet and correct heel varus.
- What are the structures at risk in this approach?



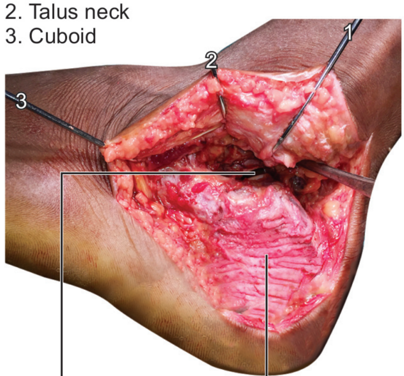


Fig. 55.6 Calcaneum: lateral approach

- Sural nerve.
- Peroneal tendons.

- What are the common surgeries performed through this approach?
  - Fixation of fracture calcaneum.
  - Calcaneal osteomyelitis.
- *Points of special interest:*
  - Three K-wire of 2–2.5 mm diameter are inserted in 3 different bone and bended in such a way to act as self-retaining retractor. The bony points are:
    - Tip of lateral malleoli
    - Neck of talus
    - Cuboid.

MID FOOT: ANTERIOR APPROACH (OLIER'S APPROACH) (FIG. 55.7)

- In what position does the patient lie on OT table?
  Supine position with slight flexion of knee.
- What is the line of incision?
  Curved incision; start just distal and posterior to lateral malleoli and run medially up to talonavicular joint.
- What dissection plane does the surgeon follow?
  Between peroneus tertius and peroneal (longus and brevis) tendons.
- Which structure is at risk in this approach?
  Skin flap itself.
- Which surgery is commonly performed through this approach?
  Triple joint arthrodesis (talocalcaneal, calcaneocuboid, talonavicular).

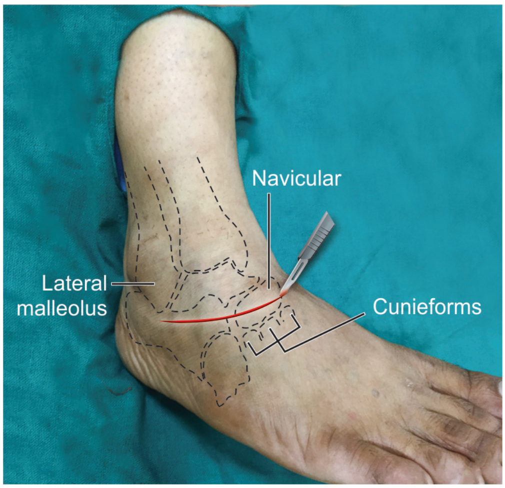


Fig. 55.7 Mid foot: anterior approach (Olier's approach)

SECTION 7

Operation Theater and Sterilization

Preeti Goyal Varshney, Upendra Kumar

Chapters

CHAPTER

56

Operation Theater Structure, Equipment and Drugs

The origin of the term 'Theatre' dates back to the time when operations were carried out in a semicircular amphitheater with the surgeon and his team performing the operation in the center and the batch of medical students and interns watching from around them. Although, the term 'operating room' (OR) has replaced the traditional name of operation theater (OT), yet OT is still widely used.

STRUCTURE OF OPERATION THEATER (FIG. 56.1)

- Why a proper OT structure is needed?
  - For longer stay of staff in operation theater
  - For taking advantages of newer techniques.
  - To secure the surgical procedure free from sepsis.

Fig. 56.1 An operation theater

- *Location of OT:*
  - Away from the noisy environment of hospital
  - Nearer to the central sterile supply unit (CSSD), surgical wards, blood bank, radiological department and laboratory.
- *Size of OT:*
  - Optimum size of 6.5 m × 6.5 m × 3.5 m.
  - Large size OT give rise to problems in airconditioning and cleaning but accommodate bulky equipment and big surgical teams.
- *Wall of OT:* Height 10–12 feet, light colored painted, semimatt finish with rounded corners (rounded corners do not allow settling of dust and microorganisms).
- *Doors of OT:* At least 1.2–1.5 m wide and sliding types as they do not give rise to turbulent air currents.
- *Floor of OT:* Easily washable, nonstaining, impervious and electroconductive. The conductive flooring avoids the hazards of electrocution and explosion.
- *Ceiling of OT:* Caved junction of wall and ceiling, easily washable and moisture proof.
- *Corridors:* Wide enough (>2.85 m) for easy movement of personnel, stretcher and machines.
- *Scrub area:* One scrub area for each OT for 2–3 persons at a time. Elbow taps are placed at least 10 cm above wash basin.

ZONING PLAN OF OPERATION THEATER (FIG. 56.2)

- *Basis of zoning:* The OT complex is divided into 4 zones, based on varying degrees of cleanliness in which the bacteriological count progressively diminishes from the outer to the inner zones and is maintained by a differential decreasing positive pressure ventilation gradient from the inner zone to the outer zone.
- *Different zones of OT are:*
  - Outer protective zone
  - Middle clean zone
  - Inner sterile zone (100% sterility is maintained in this zone)
  - Disposal zone.
- *Advantages of zoning concept:*
  - Minimum risk of hospital infection
  - Minimizes unproductive movement of staff, supplies and patients
  - Ensure optimum utilization of the OT and smooth work flow
  - Increases the efficiency of staff working in the OT.

SUB-AREAS OF THE OPERATION THEATER COMPLEX (FIGS 56.3A TO H)

- Reception.
- *Preoperative room*: Provides waiting area for preoperative patients with basic patient management facilities like oxygen and suction lines. It generally has a separate designated area for pediatric patients.
- *Post-anesthesia care unit (PACU)/post-operative room*: It contains a medication station, handwashing station, nurse station, storage space for stretchers, monitors, gas pipelines, suction outlets and ventilators.

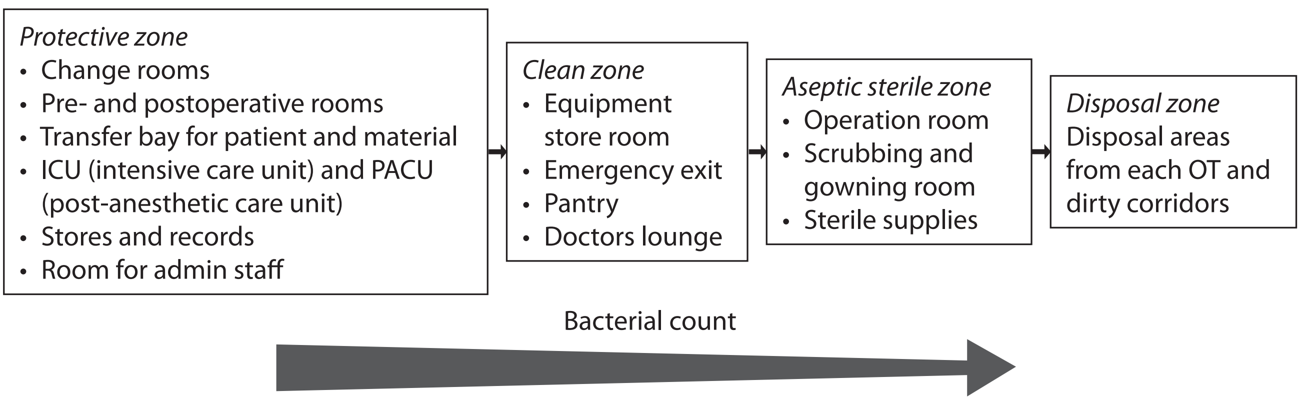


Fig. 56.2 Zones of operation theater

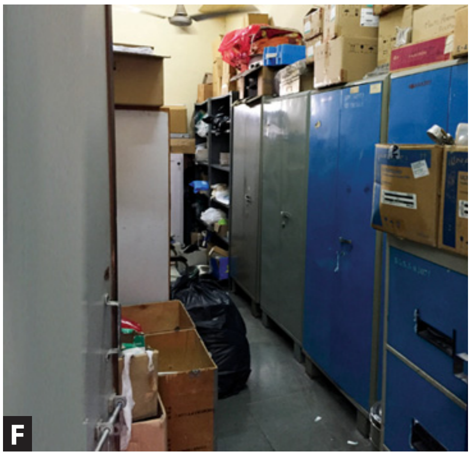
Changing room

Washing area

Preoperative room

Postoperative room

Doctors room



Store room

Figs 56.3A to F

G

Sterilization room

H

Gas cylinder storage area

Figs 56.3G and H

Figs 56.3A to H Sub-areas of the operation theater complex

- Staff room (for medical and paramedical staff separately): with facilities of lockers, hangers and sanitation
- Offices
- *Manifold room/anesthetic gas storage area*: separate areas for storage of full and empty cylinders
- *Waiting area/hall*: For patient attendant
- *Theater sterile supply unit (TSSU)*: For storage of sterile drapes, sponges, gloves, gowns and other items.

ESSENTIAL SERVICES

- *Light in OT:* Efficient lighting enable the surgical team to operate with maximum comfort and minimum fatigue.
  - Illumination of at least 500 lux at working height in general area
  - The ratio of intensity of general room lighting to that at the surgical site is kept between 1:3 and 1:5 (minimizes eye fatigueness).
  - This contrast is maintained in corridors, scrub areas and OT, so that the surgeon becomes accustomed to the light before entering the sterile field.
- *OT light (Fig. 56.4):*
  - It is a medical device intended to assist surgeon during a surgical procedure by illuminating a local area or cavity of the patient.
  - *Features of OT light*: Shadowless, homogeneous, with an illumination intensity of 25,000–1,25,000 lux (50,000-1,00,000 lux at the center and at-least 15,000 lux at the periphery), with brightness control
  - There is no temperature rise even after prolonged use. Halogen light produces less heat and hence preferred.
  - *The CRI (color rendering index)*: 85–100. CRI is the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source).
- *Air conditioning and ventilation:* To maintain the aseptic conditions of the operating room, the temperature, humidity and rate of air changes per hour are mostly taken into consideration (Fig. 56.5).
  - *Advantage of optimum OT environment:*
    - reduces the postoperative infection rate
    - reducing the fatigability rate of operating team
    - maintain the vital functions of the patient by providing a comfortable periphery.

Fig. 56.4 OT light

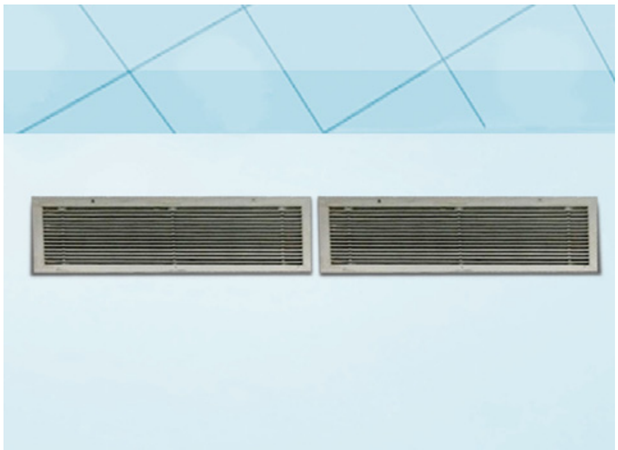


Fig. 56.5 Air conditioning system

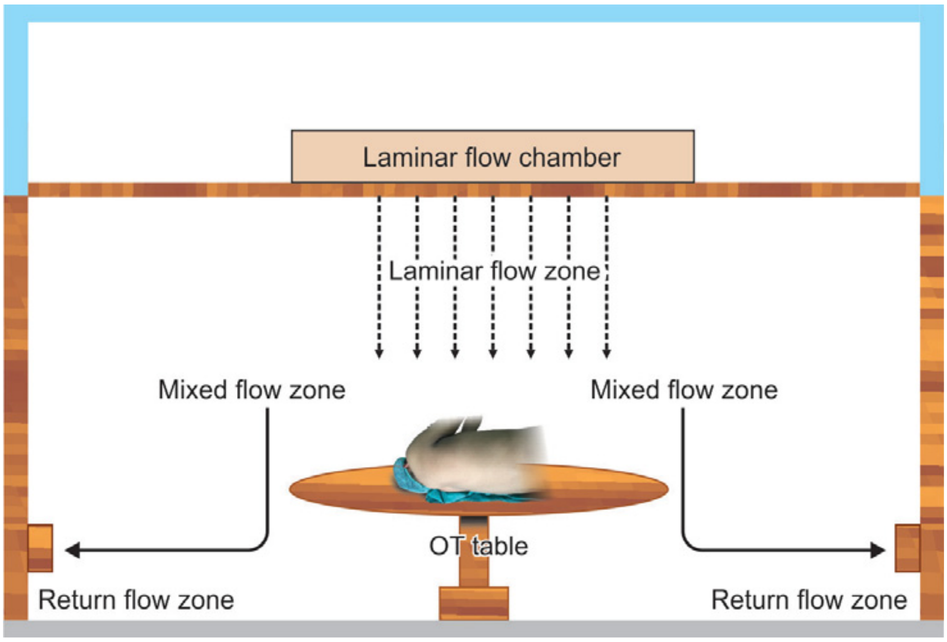


Fig. 56.6 Laminar flow system in OT

– *Optimum OT environment:*

Air temperature:18–24°C.
Humidity: 40–60%.
Air changes: 18–20 times/hour.
Positive pressure of 5 cm H_2O from ceiling to downwards and outwards to push out air from OT. The pressure gradient is kept highest in the sterile zone

- *Laminar flow system in OT:* Although 100% fresh air is considered ideal, but the cost of air-conditioning of fresh air becomes prohibitive. Hence by using HEPA (high efficiency particulate air filters), up to 75–80% of the theater room air can be recirculated (Fig. 56.6).
  - It works to create a unidirectional flow of air free from eddies and turbulence.
  - It helps to reduce the postoperative wound infection.
  - It comprises a continuous flow of highly filtered ultraclean air of less than 10 colony forming units per cubic meters (<10 cfu/m^3) of bacteria.
  - Laminar flow systems operate either by a horizontal or vertical system:
    - Horizontal system-here high efficiency particulate air (HEPA) filters are

installed on one of the operating theater walls.
- *Vertical system:* The vertical configuration involves ceiling mounted HEPA filters which direct air vertically downwards into the operative field.
- There is also a concept of ultraclean laminar air flow such that the filtered air delivery must be 90% efficient in removing particles more than 0.5 mm.

- *Water:* There is a provision of continuous, clean and soft water supply, mostly by a separate water storage tank to ensure continuous flow.
- *Fire-fighting equipment (Fig. 56.7):*
  - All inflammable materials are kept in clean area at a safe place.
  - Fire fighting extinguishers and smoke detecting alarms are placed in the OT at appropriate places and staff is trained, in their usage, in case emergency arises.
- *Pipeline/pendant service:*
  - Two ceiling pendants are recommended one for surgical team and one for anesthetist.
  - Surgical pendant has outlet for compressed air for driving drill machine, laparoscopic gas, vaccum (suction) and electrical sockets.
  - Anesthetic pendant is retractable, and provide a shelf for monitoring equipment. It has outlets for various anesthetic gases, vaccum, scavenging terminals and electrical sockets.

Fig. 56.7 Fire fighting equipment

- *Drainage system:* Must be effective and well planned.

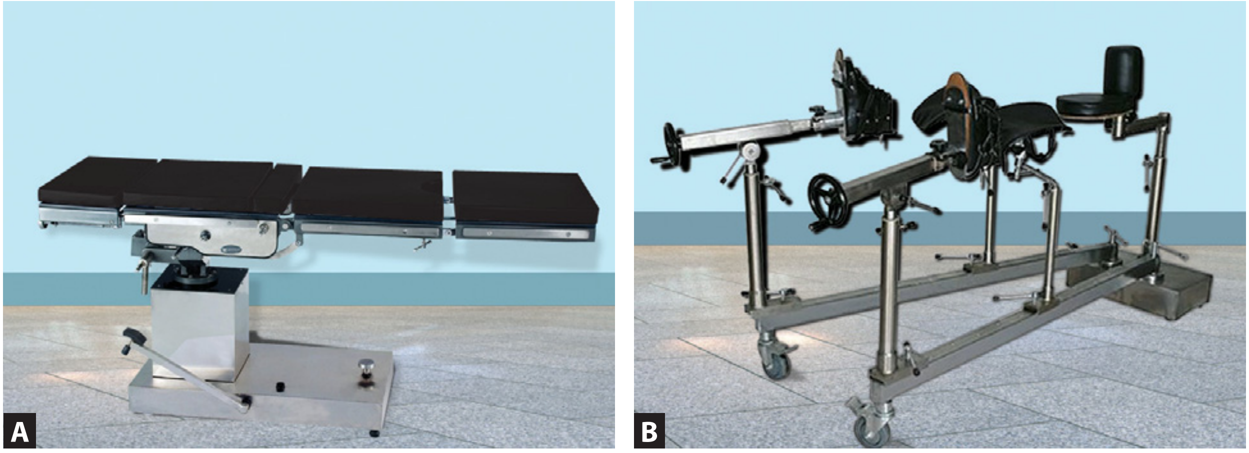
SAFETY HAZARDS IN OT

Measures to reduce the hazards due to static electrical discharge and open flames are:
- Use of explosion proof wiring and electrical equipment with frequent check by a competent person.
- Electrical installations are kept at a height of at least 1.5 m from the floor.
- Equipment such as suction, cautery diathermy should be well insulated and grounded.
- Floor should be conductive.
- Wool, rayon, silk, and outer clothing should not be permitted.
- Concentration of gases should be reduced by ventilation (air changes 20 per hour).
- Exhaust fans should be fitted at the floor level and not at the ceiling level.
- Furniture and equipment touching the floor should be of conductive material or grounded by a drag chain. Pads, tubings, beltings should have conductive qualities.
- Storage areas for combustible gases should not be in the operating areas. While dealing with explosive anesthetic gases, utmost care is taken.
- Fire fighting equipment must be readily available in the OT at certain important places and staff should be trained.

A BRIEF OVERVIEW ABOUT EQUIPMENT INSIDE OT

OPERATION TABLE (FIGS 56.8A AND B)

- It is the table on which the patient lies during a surgical operation.
- Features of a OT table:
  - Dimension of table; up to 83 inches in length (can be shortened by removing auxillary extensions) and 20–24 inches in width.



Figs 56.8A and B Operation table with orthopedic traction unit

- Table height should be adjustable having provision of tilt in different direction.
- Table segments are also adjustable so that body parts and extremities can be kept in suitable position for operation.
- Table should be well padded.
- Table is designed in such a way that all necessary medical devices can easily be brought to the operating area and positioned. For example, X-ray or C-arm can easily be slide under the table top.

ANESTHESIA MACHINE AND GAS CONNECTIONS (FIG. 56.9)

- Continuous flow anesthesia machine dates back to the first availability of compressed gases, and despite numerous modifications, the modern apparatus retains many of the features of the original Boyle's machine.
- The term work station is frequently used for newer machines, as they also have inbuilt monitor and ventilator besides having the basic features of anesthesia machine
- *Functioning of a anesthesia machine:*
  - Pressurized gases are supplied by cylinders or pipelines to the anesthetic machine.
  - Anesthetic machine controls the release of pressurized gases at preset rates
  - It adds inhalational anesthetic vapours (like isoflurane, sevoflurane, etc.) to the gases as required and delivers the mixture to a common gas outlet.
  - From common gas outlet, the gases are transferred to the patient through the breathing circuit.

Fig. 56.9 Anesthesia machine

ANESTHESIA EQUIPMENT KIT (FIG. 56.10)

Commonly used equipment are highlighted here:

- *Laryngoscope:* It is a device that has been used to visualize the interior of the larynx including the vocal cords so as to aid endotracheal intubation.
- *Anatomical face mask:*
  - It is used to provide oxygen and other anesthetic gases to the patient before

Fig. 56.10 Anesthesia equipment kit (from left to right, clockwise–Bains breathing circuit, endotracheal tube, laryngeal mask airway, anatomical face mask, laryngoscope, simple face mask, epidural and spinal needles, nasal and oral airways)
(*Courtesy:* Dr Preeti Goyal Varshney)

placing a definitive airway device like endotracheal tube.
- 100% oxygen can be provided through it, if a proper seal is made.
- Anatomical mask is available in various sizes.

- *Simple face mask:*
  - It is used to supplement oxygen intraoperatively to the patients who have received sedation along with regional block.
  - It is also used for postoperative patients after receiving general anesthesia or those who require supplementary oxygen due to some comorbidity, elderly or pediatric patients.
  - Maximum oxygen concentration which can be provided is 60%.
- *Oropharyngeal and nasal airways:*
  - An airway is a device which when inserted into the oropharynx or nasopharynx, helps to maintain the patency of air passage for unobstructed breathing.
  - These airways are available in various lengths and diameters.
- *Laryngeal mask airway (LMA):*
  - It is a supraglottic airway device used for anesthesia and maintaining patency of the upper airway.
  - It forms a low pressure seal around the laryngeal inlet and thus permits gentle positive pressure ventilation.
  - Different sizes are available, appropriate size to be used according to body weight of the patient.
- *Endotracheal tube*: An endotracheal tube is a device used to secure a patient's airway. It can be inserted via the oral or nasal route.
- *Breathing circuit*: A breathing circuit is an assembly of components which connects the patient's airway to the anesthetic machine creating an artificial atmosphere, into and from which the patient breathes.
- *Spinal and epidural needles:*
  - Spinal needles are used to give sub-arachnoid block (16–30 gauge size).
  - The needles are either sharp or blunt at the tip with either end-injection or side injection and either sharp or round (blunt) bewel edges.
  - The standard epidural needle is typically 16–18 gauge.
  - The epidural needle has a blunt bevel with a gentle curve that allows the needle to pass through the ligamentum flavum and abut against dura, pushing it away, rather than penetrating it. This creates the negative pressure that identifies the epidural space.

MULTIPARA MONITORS (FIG. 56.11)

- This is used in the operating room for intraoperative monitoring, as well as in

Fig. 56.11 Multipara monitors

Fig. 56.12 Defibrillator

postoperative room for postoperative monitoring.
- The main parameters monitored are- electrocardiogram (ECG) with heart rate (HR), oxygen saturation (SpO_2 or pulse oximetry) with pulse rate (PR), non-invasive blood pressure (NIBP), respiratory rate (RR), temperature and end tidal carbondioxide ($EtCO_2$).

DEFIBRILLATOR (FIG. 56.12)

- A charged defibrillator is always kept ready in OT to handle any life threatening arrhythmias or cardiac arrest.
- The purpose of defibrillation is to apply a controlled electrical shock to the heart, which leads to depolarization of the entire electrical conduction system of the heart, so that, SA node takes over.

DRUG CART (FIG. 56.13)

- It consists of systematic arrangement of all the drugs used in an OT. Only the drugs which do not require cold storage, can be kept in it.
- The main drugs present in a drug cart are:
  - Resuscitation drugs (atropine, adrenaline, amiodarone, metoprolol)
  - Anesthetic agents (thiopentone, succinyl choline, vecuronium),
  - Local anesthetics (lignocaine, bupivacaine),

Fig. 56.13 Drug cart

  - Opioids (fentanyl, morphine)
  - Vasopressors (dopamine, noradrenaline, dobutamine),
  - Hypotensive agents (nitroglycerine, labetalol)
  - Antiepileptics (diazepam, phenytoin)
  - Hemostatic agents (tranexamic acid)
  - Others like glycopyrrolate, ranitidine, metoclopramide, ondansetron, furosemide, midazolam, neostigmine, sodium bicarbonate, etc.
- ***Hemostatic agents***: To combat the intraoperative surgical bleeding, hemostatic agents may be required sometimes.
  - *Tranexamic acid:*
    - An antifibrinolytic agent and thus promotes clot stability.
    - Especially useful in controlling bleeding from skin and mucosal surfaces.

- Given by intravenous infusion in the dose of 500 mg, repeated 2–3 times daily, some orthopedicians prefer to give a single bolus of 1 gm IV before starting hip surgery. Oral preparations are also given in postoperative period.
- *Epsilon amino caproic acid:* It has a shorter plasma half life, is less potent and is more toxic (gastrointestinal upset).
- *Desmopressin:* It is the treatment of choice for patients with mild or moderate hemophilia A.

- ***Local anesthetics:*** Used for regional nerve blocks and neuraxial anesthesia (spinal and epidural). Surgeons also use these agents for local infiltration for small procedures. The main agents used are:
  - *Lignocaine:*
    - It is a fast acting local anesthetic (onset is within 2–5 minutes of injection)
    - Used in the concentration of 1–2%
    - Lignocaine mixed with small amounts of adrenalin (1:2,00,000) is available to allow larger doses to be used and to make it last longer
    - Maximum recommended dose is 3–4 mg/Kg (without adr) and up to 7 mg/Kg (with adr).
    - Accidental intravenous injections of large doses may cause perioral muscle twitching, confusion, numbness and sometimes convulsions.
    - It is also used as an antiarrhythmic agent.
  - *Bupivacaine:*
    - It has a slower onset of action (5–15 minutes after injection), but its effect lasts longer (4–8 hours), even without adrenaline.
    - It is mainly used for nerve blocks and neuraxial anesthesia (spinal and epidural).
    - The maximum recommended dose is 2–3 mg/kg, used in the concentration of 0.25–0.5%.
    - Intravenous injections can lead to perioral twitching, ringing in the ears, change in vision and can also be fatal by causing arrhythmias and cardiac arrest due to its cardiotoxicity.
  - *Ropivacaine:* It has almost same pharmacological profile as bupivacaine but is less cardiotoxic. The motor block may not be as good as bupivacaine.

ELECTRICAL SURGICAL CAUTERY UNIT (FIG. 56.14)

- The cautery machine is kept near the OT table and the cautery probe (used at surgical site) is attached to the machine.
- It can be hand controlled or foot pedal controlled by surgeon.
- The cautery tip can be unipolar or bipolar.
- It is used for the purpose of cutting and coagulation of body tissue with a high frequency electrical current during surgical procedures to prevent or stop bleeding during tissue dissection or to remove abnormal tissue growth by cutting.

SUCTION MACHINE (FIG. 56.15)

- Suction device may be mechanical hand-pumps or battery or electrically operated.
- Generally 100–150 mmHg pressure is adequate for most purposes.
- The plastic, rigid **Yankauer** suction tip is the most common type of tip attached to a suction unit.

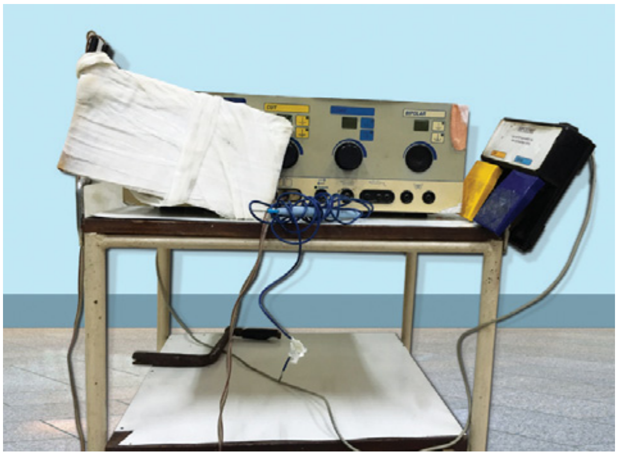


Fig. 56.14 Electrical surgical cautery unit

Fig. 56.15 Suction machine

Fig. 56.16 A pneumatic tourniquet system (automatic)

- *Uses:*
  - Suction is used to clear the blood from the surgical field on to allow the surgeons to view and work on that area.
  - It is also used by anesthetists to clear the airway of blood, saliva, vomit, etc.

TOURNIQUET (FIG. 56.16)

- The pneumatic tourniquet applies pressure to the limb to restrict the blood supply to the operative limb.
- It is a useful aid for limb procedures as it decrease the blood loss during surgery and provide a relatively bloodless field for the surgeon if used properly (for detail, refer Chapter 7).

FLUID COMPRESSION BAG OR PRESSURE INFUSION BAG (FIG. 56.17)

- A handy compact thing, in which the fluid unit is loaded and is compressed by inflating the pressure bag.
- It is very useful when the patient is bleeding profusely and large amount of fluid has to be given intravenously in very small time to stabilize the patient hemodynamically.
- It is not used for fluids supplied in glass bottle preparation.

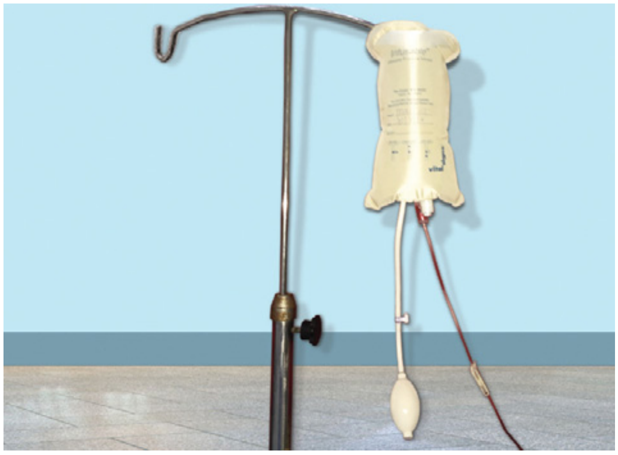
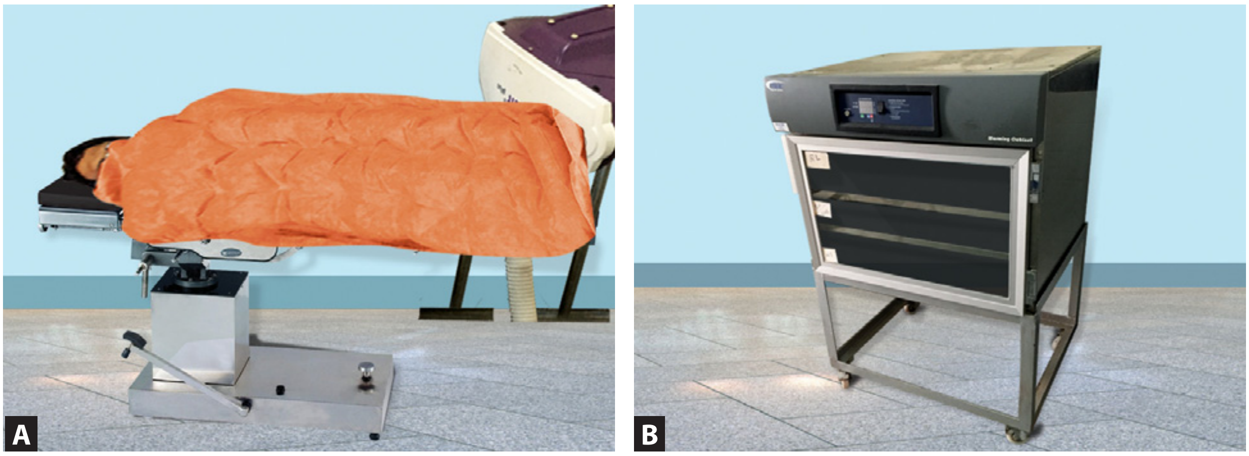


Fig. 56.17 Fluid compression bag or pressure infusion bag

WARMING DEVICE (FIGS 56.18A AND B)

- *Purpose:* Anesthetized patient cannot regulate its body temperature. Hence to maintain normothermia in a patient especially in cold OT surroundings, a patient warming device may be required.
- *Common devices:*
  - *Electrical warming blankets:* It creates a warm surrounding around patient.
  - *Fluid warmers:* It warms IV fluids, which further helps in maintaining normo thermia by avoiding cold IV fluid transfusion.



Figs 56.18A and B Warming device: (A) Electrical warming blanket; (B) Fluid warmers

OT TROLLEY (FIG. 56.19)

It is the sterile trolley which is prepared before each surgery, with the required instruments for the proposed surgical procedure.

STERILIZED DRUMS AND BOXES (FIG. 56.20)

Number of sterile drums and boxes, containing bandages, mops, gauge pieces and other sterile instruments to be used for surgery are seen in OT and in sterile area.

ARTHROSCOPE TROLLEY (FIG. 56.21)

- It is a movable trolley with shelves to keep various equipment for arthroscopy.
- These are light source with cable, monitor, camera and other accessories.

RESUSCITATION TROLLEY (FIG. 56.22)

- It consists of all life saving drugs and equipment along with oxygen cylinder and suction machine.
- It is kept ready all the time to handle any adverse condition.
- *The various injectable drugs kept are:* Adrenaline, atropine, dopamine, dobutamine, nor adrenaline, labetalol, nitroglycerin, metoprolol, amiodarone, hydrocortisone, dexamethasone, diazepam, phenytoin,

Fig. 56.19 OT trolley

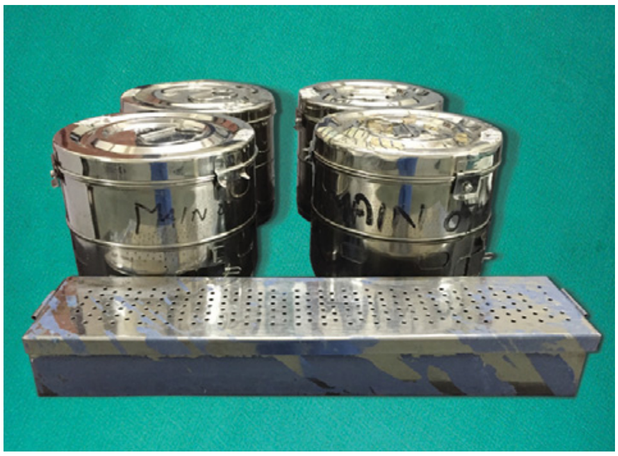


Fig. 56.20 Sterilized drums and boxes

Fig. 56.21 Arthroscope trolley

Fig. 56.22 Resuscitation trolley

calcium gluconate, sodium bicarbonate, potassium chloride.

- *The equipment are:* Laryngoscope with various size blades, masks of different sizes, oral and nasal airways, endotracheal tubes, stylet, breathing circuit, laryngeal mask airways, AMBU, suction catheters, gloves.

IMAGE INTENSIFIER (C-ARM) (FIG. 56.23)

- This a portable X-ray machine that acts on the principle of fluoroscopy which convert low intensity X-ray into a conveniently bright visible light output.
- Two screen sizes 6” or 9” are commonly used.
- It has been proved to be the eye of orthopedician in present era.
- A lead apron must be used by OT personnel when C-arm is working inside the OT. The 0.5 mm lead thickness equivalence is usually preferred.

Fig. 56.23 Intensifier with monitor

WASTE DISPOSAL UNIT (FIGS 56.24A AND B)

- Color coded waste disposal units along with a sharp disposal unit.
- Sharp disposal unit consists of electrically operated needle destroyer by burning and a container for safe storage and disposal of contaminated needles.

Figs 56.24A and B (A) Waste disposal unit; (B) Needle burner and cutter

MISCELLANEOUS EQUIPMENT

Miscellaneous equipment are described below; (Figs 56.25A to F).

Figs 56.25A to F Miscellaneous equipment. (A) Patient transfer trolley; (B) IV fluid stand; (C) foot steps; (D) OT board; (E) OT bolster; (F) X- ray view box

CHAPTER

57

Principles of Sterilization

All medical practitioners should be concerned with the cleanliness of their equipment, both to prevent spread of infection between patients and to ensure that they themselves do not contract an infection. The Center for Disease Control (CDC) defines healthcare associated infections (HAIs) as infections that patients acquire during the course of receiving treatment for other conditions or healthcare workers (HCW) acquire while performing their duties within a healthcare setting. The prevention of HAI depends upon several factors including effective cleaning, sterilization and disinfection procedures, performed carefully with goal of minimizing contamination by pathogens.

DEFINITIONS

To understanding the principle of sterilization everyone must be acquainted with some basic terminologies pertaining to it.

- *Antimicrobial:* A chemical or material capable of destroying or inhibiting the growth of microorganisms.
- *Antiseptic:* A chemical germicide that has antimicrobial activity and that can be safely applied to living tissue.
- *Asepsis:* A scheme or process that prevents contact with microorganisms.
- *Bioburden:* The number and types of viable organisms contaminating an object.
- *Cleaning:* Removal of foreign material from an item.
- *Disinfectant:* Chemical germicide formulated to be used on inanimate objects.
- *Disinfection:* Disinfection is a process that eliminates most of the pathogenic microorganisms but not spores.
- *Level of disinfection:*
  - *High level:* Kills all organisms except spores.
  - *Intermediate level:* Kills vegetative bacteria including *Mycobacterium tuberculosis*, most fungi and viruses (lipid and nonlipid) but not spores.
  - *Low level:* Kills vegetative bacteria (not *Mycobacterium*), some fungi and viruses (lipid and some nonlipid) but no spores.
- *Sterile/sterility:* State of being free from all living microorganisms.
- *Sterilization:* Process capable of removing or destroying all viable forms of microbial life, including bacterial spores, to an acceptable sterility assurance level.

CLASSIFICATION OF ITEMS AND THEIR DECONTAMINATION TECHNIQUES

Spaulding has classified all the items in three main group:

Classification of items and their decontamination technique			
	Noncritical	*Semicritical*	*Critical*
Definition	Items that come in contact with normal or intact skin	Items that come in contact with mucous membrane or nonintact skin	Items that penetrate sterile areas such as body cavities and the vascular system
Items	Wall, floor, ceiling, furniture, sink, blood pressure cuffs, crutches, bed rails, linens	Respiratory equipment, flexible endoscopes, laryngoscopes, spatula, endotracheal tube, thermometer, similar instruments	Surgical instruments, cardiac, intravascular, urinary catheters, implants, ultrasound probes which are introduced into body cavities and vascular system
Decontamination	Cleaning and low level disinfection	Cleaning and high level disinfection or sterilization	Cleaning and sterilization

- Noncritical
- Semicritical
- Critical.

CLEANING

- The first and the most important step in decontamination is thorough cleaning. Cleaning is designed to remove rather than to kill microorganisms. If an article is not clean, retained salts and organic soil could inactivate chemical germicides or protect microorganisms during the disinfection and sterilization process.
- *Where cleaning should perform:* Cleaning should be performed in a designated area to minimize inadvertent personnel exposure or exposure of other items to contaminants.
- *Method of cleaning:*
  - Cleaning may be accomplished manually, mechanically (washer/disinfectors or ultrasonic cleaners) or by a combination of both.
  - The material used for cleaning are simple water and detergents, hot water in the range of 60°–95°C and high frequency and high energy ultrasonic waves.
- *Post-cleaning measure:*
  - *Rinsing:* After cleaning, rinsing should be performed to remove soil and residual detergent on the equipment.
  - *Drying:* Rinsed items are subjected to towel or air drying. Air drying cabinets and hot air ovens are meant for this purpose. Drying is important because a humid environment may encourage the growth of certain organisms.
  - *Testing for cleanliness:* After cleaning, each item should be inspected to verify cleanliness and tested for functionality. Disassembled devices must be reassembled to perform functionality testing.

CHEMICAL DISINFECTION AND PASTEURIZATION

A disinfectant is usually a chemical agent, but some process (such as Pasteurization) are also disinfecting.

- *Chemical disinfection*: This process involves immersing an item in a solution that contains a disinfectant. This method is especially useful for heat sensitive equipments.
- *Factors influencing Chemical disinfection:*
  - *Concentration of the chemical:* Higher concentrations preferred (except alcohols).
  - *Temperature:* Higher temperatures preferred.
  - *Evaporation and deactivation by light:* Specially chlorine product.

- *Bioburden:* Longer exposure for higher bioburden of pathogens.
- *pH:* Increase in pH tends to decrease the efficacy of phenols, iodine and hypochlorites while improves that of glutaraldehyde and quaternary ammonium compounds.
- *Surface characteristic:* Uneven or porous surfaces resist chemical disinfection.
- *Time:* Minimum contact time of 20–30 minutes is recommended.

- *Disadvantages of chemical disinfection:*
  - It cannot be used for all types of equipment.
  - It is more expensive, less effective and more prone to human errors than steam sterilization.
  - Some solutions are irritating to tissues and have unpleasant odors.
  - Lack of a good method (only patient outcome) of validation for disinfection.

Pasteurization

With pasteurization (hot water disinfection), the equipment is immersed in water at an elevated temperature (but below 100°C) for a specified time. A typical sequence is 30 minutes at a temperature of 70°C. Contact time is inversely related to temperature. It is a high to intermediate level disinfection process.

- *Advantages:*
  - The lower temperature is less damaging to equipment than the higher temperatures employed during autoclaving.
  - There are no toxic fumes or residues.
  - It is simple, inexpensive and reliable.

Comparison of various chemical disinfectants

Disinfectant	*Level of disinfection*	*Advantages*	*Disadvantages*	*Use*
Glutaraldehyde	High	Wide microbicidal activity (including sporicidal), extensive shelf life, noncorrosive	Evaporates at room temperature, health hazard (headache, skin, eye and mucous membrane irritation, neutralizer should be added at the time of disposal	2% with alkaline pH is used for sutures, sharp instruments, laminated nonautoclavable equipments, like laparoscopes. (Contact time 20–30 min)
Orthophthaldehyde (OPA)	High	Noncorrosive, minimal odor, no need for activation or change in pH	Stains proteins, repeated contact may cause dermatitis	Can be used in place of glutaraldehyde, contact time (5–12 min)
Peracetic acid	High	Effective in the presence of organic matter, decomposition products are not harmful	Corrosive, costly	Can be used on a wide variety of instruments and equipment via Steris System
Hydrogen peroxide	High	Not inactivated by organic matter, no restrictions on disposal	Loses effectiveness when exposed to heat and light, to be used in correct concentration	Used as 7.5% for 30 min contact time for many instruments. Also used for fogging of OT

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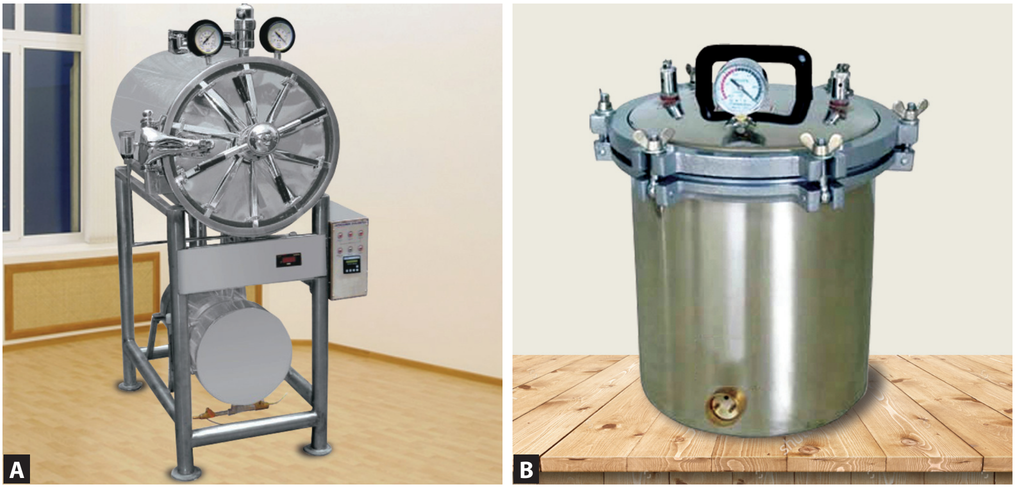
Contd...

Disinfectant	*Level of disinfection*	*Advantages*	*Disadvantages*	*Use*
Formaldehyde	High	Noncorrosive, not inactivated by the presence of organic matter	Potentially toxic, flammable, irritant	Used for fumigation of OT, disinfection/ sterilization of cautery wire
Iodine compounds (iodophores)	Intermediate	Residual activity present, cheap, easily available	Corrosive, staining or discoloration	Used for hand scrubbing, skin preparation before surgery
Chlorine compounds (e.g. sodium hypochlorite)	Intermediate	Inexpensive, fast acting	Corrosive, irritant, inactivated by organic matter, instability (short shelf life)	Used for disinfecting surfaces, water, some equipment
Phenolic compounds	Intermediate to low	Active in the presence of organic matter, cheap, easily available, residual activity present	Bad odor, irritating to the skin, absorbed by rubber, difficult to rinse	Useful for surface disinfection
Alcohols	Intermediate to low	Wide microbicidal activity, non-corrosive	Flammable, tend to swell and harden rubber and certain plastics with repeated use	Used for skin (hand) disinfection, and for final rinse of endoscopes after chemical disinfection
Quaternary ammonium compounds (quats)	Low	Quick acting, non-toxic, noncaustic, do not produce noxious fumes	Ineffective against spores, *Mycobacterium*, hepatitis B virus	Used for cleaning and disinfecting environmental or house keeping surfaces

- *Disadvantage:*
  - The treated equipment is wet and must still be dried and packaged, during which time it may again become contaminated.
  - The heat may damage some materials.

STEAM STERILIZATION (AUTOCLAVING) (FIGS 57.1A AND B)

- It utilizes saturated steam under pressure. Pressure per se has little or no sterilizing effect. It is the moist heat at a suitable temperature, as regulated by the pressure in the chamber, that brings out sterilization.
- *Duration of sterilization:*
  - Increasing the temperature dramatically reduces the time needed to achieve sterilization.
  - The minimum time for sterilization by steam at 121°C is 15 minutes.
  - If the temperature is 126°C, the time is reduced to 10 minutes. It is 3.5 minutes at 134°C and only a few seconds at 150°C.
- *Problems with steam sterilization:*
  - *Steam quality:* Steam is saturated when it has the proper balance of pressure and temperature.
  - *Presence of air in the chamber:* Impairs sterilization.



Figs 57.1A and B Steam sterilization (Autoclaving)

 - *Malfunctioning equipment:* Like out-of-calibration temperature or pressure gauges, faulty or maladjusted control valves, malfunctioning cycle sequence controllers.
 - *Personnel errors:* Like inadequate cleaning, incorrect packaging methods, poor loading techniques.
- *Monitoring of steam sterilization:*
 - *Mechanical indicators:*
   - Mechanical monitors indicate time, temperature and pressure.
   - There should be a permanent record of these parameters.
 - *Chemical indicators:*
   - The most common example is autoclave tape.
   - Another example is the temperature tube that contains a chemical that melts and sometimes changes color when the appropriate temperature is attained.
 - *Biological indicators:*
   - These are the standardized preparation of spores (typically strips or ampoules) that are placed in the most difficult-to-sterilize location in the load.
   - The indicators are exposed to the sterilization cycle, retrieved, incubated and examined for microbial growth.
   - A positive biological indicator is indicative of a possible sterilization process failure.
- *Advantages of steam autoclaving:*
 - Steam autoclaving can kill all bacteria, viruses and spores.
 - Speed, good penetration, economic, ease of use and reliable.
 - No toxic products or residues
 - The material can be prepackaged and kept sterile until used.
 - It poses no harm to the environment.
- *Disadvantages of steam autoclaving:*
 - Damaging of few susceptible equipment if subjected to steam.
 - Autoclaving can cause blunted cutting edges, metal surface corrosion and shortened life of electronic component.
- *Flash sterilization:*
 - It is a modification of conventional steam sterilization in which the flashed item is placed in a specially designed, covered, rigid container to allow for rapid penetration of steam.

- It is not recommended as a routine sterilization method because:
  - The lack of timely biological indicators to monitor performance.
  - Absence of protective packaging following sterilization.
  - Possibility for contamination of processed items during transportation to the operating rooms.

Dry Heat Sterilization

- Dry heat is used for items that might be damaged by moist heat. Although slow but penetrates well and does not corrode metal and sharp instruments.
- Times and temperatures frequently used for dry heat sterilization are 170°C for 60 minutes, 160°C for 120 minutes and 150°C for 150 minutes.
- It is useful for nonaqueous liquids or semisolids such as talc, glycerin, oils, petroleum jelly, waxes and powders.

ETHYLENE OXIDE STERILIZATION (FIG. 57.2)

- *Properties of ethylene oxide:*
  - Ethylene oxide (EO) is a colorless, poisonous gas with a sweet odor.
  - It is flammable in concentrations of 3% or greater but mixtures containing up to 12% EO in the inert diluents like carbon dioxide are nonflammable and posing their sterilizing ability.
  - It penetrates into crevices and through permeable bags and kills bacteria, spores, fungi and viruses.
  - EO does not penetrate dried protein material. Therefore, equipment must be thoroughly cleansed and rinsed before sterilization.
- *Optimum environment of EO chamber:*
  - A relative humidity between 35% and 70% and a temperature of 18°–22°C throughout the processing and storage facility are recommended.
  - Items should be loaded loosely to allow gas to penetrate throughout the load.
- *Duration:* The time generally ranges between 1.5 and 6 hours in automatic sterilizers.
- *Complications of EO sterilization:*
  - *Patient complications:* Like skin reactions, laryngotracheal inflammation, hemolysis, increased risk of latex sensitization.
  - *Equipment alteration:* Repeated exposure of some plastics to EO and heat may leach plasticizers and weaken their structural integrity.
  - *Personnel complications:*
    - Acute and significant exposure leads to an irritant response, upper respiratory complications, eye irritation, headache, blunting of taste or smell and coughing frequently occur.
    - Chronic exposure can affect the eyes, the central and peripheral nervous system and skin.
    - EO is a recognized mutagen, carcinogen and may adversely affect the reproductive system.

Fig. 57.2 Ethylene oxide sterilization

- *Advantages of gas sterilization:*
  - It is very reliable because the gas penetrates into crevices, narrow lumens, and regions blocked by the liquids.
  - It can be used on a wide variety of items, including those that would be damaged by heat or moisture.
  - Items can be packaged before sterilization and stored sterile for extended periods.
  - A large amount of equipment can be sterilized at one time.
- *Disadvantages of gas sterilization:*
  - There is a risk of fire and explosions.
  - Total processing time required is long and thus it is necessary to have multiple sets of equipments.
  - More costly than other types of sterilization.
  - Personnel need to be highly trained and supervised.
  - Measures to reduce employee exposure and monitor levels of EO must be taken.
  - It cannot be used to sterilize devices that have petroleum based lubricants in or on them, because EO cannot penetrate these.

SOME OTHER METHODS OF STERILIZATION

Ozone

- *Principle:* Ozone sterilizers use oxygen, water and electricity to produce ozone. The gas is humidified and dispersed into a sterilization chamber. It is compatible with most anodized aluminum sterilization containers and all plastic containers.
- *Advantage*: Ozone sterilization is good for most goods that need low temperature sterilization.
- *Disadvantage*: It is unsuitable for the devices that contain natural gum, rubber products, some plastics, and some metals such as brass and copper.

Radiation Sterilization (Fig. 57.3)

- *Principle:* Gamma radiation uses an electromagnetic wave produced during the disintegration of certain radioactive elements. If the dosage applied to a product is large enough, all microorganisms including bacterial spores and viruses will be killed.
- *Advantages:*
  - The treated item remains sterile indefinitely until the packaging seal is broken.
  - As there is no temperature rise during treatment, thermolabile materials can be sterilized.
  - Items may be used immediately after treatment with no risk from retained radioactivity
- *Disadvantage:* It requires expensive equipment and is used only by large manufacturers to sterilize disposable equipment.

Gas Plasma Sterilization

- *Principle:* Gas plasma is sometimes described as the fourth state of matter,

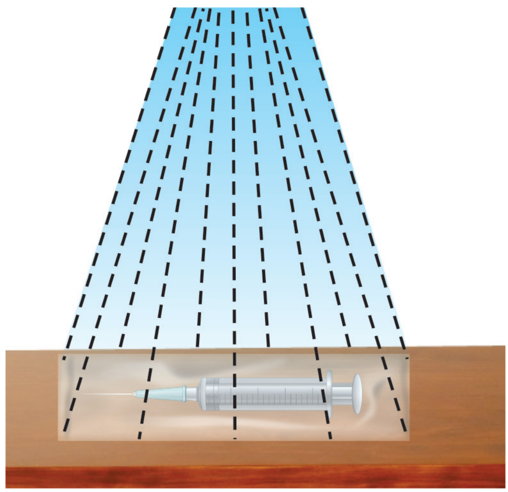


Fig. 57.3 Radiation sterilization

consisting of a cloud of reactive ions, electrons and neutral atomic and molecular particles. It is produced by applying energy to certain gases. Hydrogen peroxide vapor is most often used. The reactive species in the plasma interact with the molecules that are essential for the metabolism and reproduction of living cells.

- *Advantages:*
  - It can be used for most heat labile and moisture-sensitive items.
  - It is simple to operate and uses low concentrations of sterilizing agent.
  - The sterilized products are dry and immediately available for use.
  - There is no need for aeration or cool down time.
  - There are no emissions or toxic byproducts.
  - No personnel or exhaust monitoring is required.
  - No water source, heating or outside venting is require
- *Disadvantages:*
  - Cellulosic materials (linen, paper, cotton), powder, liquids, implants, and devices containing long, narrow, dead end lumens.
  - Require synthetic packing and special container.

STERILIZATION OF OPERATION THEATER

- In spite of brief stay of patients in the operation theater, the environment of OT plays a great role in the onset and spread of infections.

Advantages and disadvantages of different methods of sterilization

Method	*Advantages*	*Disadvantages*
Chemical sterilization	It is speedy, economic and simple. This is especially important in endoscopy suites because it enables equipment to be used several times a day. It is useful for equipment that does not require sterilization but does require high level disinfection.	Not useful for all types of equipments, more expensive, less effective and more prone to human errors. Some solutions are irritating to tissues and have unpleasant odors, lack of a good method of validation of disinfection, only indirect monitoring for efficacy.
Steam (autoclaving)	Nontoxic, cycle easy to control and monitor, rapid microbicidal action. Penetrate medical packing and lumens of devices.	Deleterious for heat sensitive and sharp instruments. May leave instrument wet causing them to rust.
Dry heat sterilization	Does not corrode metal and sharp instruments, useful for non-aquous substances like talc, petroleum jelly	Slow, not frequently used.
Ethylene oxide (EO)	Penetrate packing material and device lumen. Simple to operate and monitor. Compatible with most medical devices.	Toxic, carcinogen and flammable lengthy cycle and aeration time.
Ozone	Used for metal and plastic instruments including some instruments with lumen	Limited clinical use and limited microbial efficacy.
Gamma-radiation sterilization	Any package can be used, for thermolabile items also, non-hazardous	Costly, requires expensive large set-up for sterilization process.
Gas plasma (hydrogen peroxide)	Nontoxic, used for heat and moisture sensitive items. Compatible with most medical devices. Requires electrical outlet.	Cellulose (paper), linens and liquid cannot be processed. Endoscope or medical device restriction based on luminal size. Requires synthetic packing and special container.

- *How to make a OT sterilized:*
  - *General cleaning:* Cleaning is the removal of all foreign material (dirt and organic) from the object being reprocessed. Two key points of cleaning are friction to remove foreign matter and fluids to remove or rinse away contamination.
    - Spot cleaning of walls and ceiling should be undertaken as needed every day.
    - Open shelves need to be cleaned daily using detergent while closed cabinets may be cleaned once weekly.
    - The floor should ideally be sprayed and cleaned with wet pick-up vacuum cleaner after each surgical procedure and at the end of the day schedule.
    - The air-conditioning (AC) ducts are mechanically cleaned using machines, wet vacuum with detergent or by fogging with approved disinfectants.
  - *Methods of OT sterilization:* There are mainly two ways as fumigation or fogging.
    - Fumigation
    - Fogging (Fig. 57.4)
    - Other
      - *Aldekol*: A mixture containing 6% formaldehyde, 6% glutaraldehyde and 5% benzalkonium chloride
      - *Permanganate method*
      - *Paraform method*
      - *Virkon*
  - Frequency of sterilization: The frequency of sterilization depends upon the factors

Fig. 57.4 Fogging machine

Comparison between fumigation and fogging		
	Fumigation	*Fogging*
Method	After closing the windows, formalin fumes are generated and the room is kept closed for min. 8–10 hours, followed by neutralization of vapors by ammonia.	Dispersal (spray) of a disinfectant with a fogger like device in the room until all surfaces were wet, followed by wiping off residual fluid from surfaces
Agents used	Formalin with potassium permanganate, paraform	Hydrogen peroxide with or without silver nitrate, glutaraldehyde with quaternary ammonium compounds, peracetic acid
Reaction time or contact time required	At least 8–10 hours	30 min to 1 hour depending on the agent used
Carcinogenicity	Proven	Nil
Neutralization after opening OT	Required with ammonia	Not required
Readiness to use OT	Minimum 2 hours needed for neutralization after opening the OT	Can be used after 20–30 minutes of opening the OT

like number of surgeries, type of surgeries and number of personnel inside the OT.

- For a single user, single specialty OT with minimal personnel movement, weekly once sterilization is generally considered adequate.
- In between cases, simple cleaning of floor with 1% sodium hypochlorite is adequate.
- Equipments like light, monitor, anesthesia machine, diathermy, etc. should be mopped with 0.5% sodium hypochlorite or alcohol solution.
- Microbiological sampling and surveillance of OT is also recommended to prevent healthcare-associated infection.

STERILIZATION OF DIFFERENT MATERIALS

- Most of the orthopedic instruments, and implants are steam sterilized (autoclaved).
- Sharp instruments like blades or scissors are kept in cidex (glutaraldehyde 2%) for a minimum contact time of 20 minutes.
- It is also emphasized that manufacturers should always be consulted for any specific instruction for sterilization/disinfection of a specific equipment.

ORTHOPEDIC INFECTION RATE

- Standard—less than 1%
- Acceptable—1–2%
- Borderline—2–3%
- Unacceptable—more than 3%.

CHAPTER

58

Before Starting the Surgery

GOALS OF PATIENT CARE BEFORE ANY PROCEDURE

- To ensure that a standard protocol is followed before operating the patient.
- To allay the patient's anxiety and fear about the surgical procedure.
- To evaluate the comorbid conditions if any of the patient.
- To anticipate the surgical complications before the operation and also observe during and after the surgery.
- To guard the patient's safety and welfare throughout the preoperative period.
- To minimize physical discomfort, pain, or anxiety of the patient in case of acute injury.
- To maintain asepsis and prevent infection.
  Hence before taking the patient to operation theater:
  - Patient preparation is required.
  - Surgeon has to follow a few steps.
  - OT has to be kept ready for the procedure (sterile surgical trolley and equipment are kept ready by the nurse).

PREPARATION BEFORE ADMITTING THE PATIENT

- Patient will be seen by surgeon at OPD and decision to admit/or work-up as an outpatient will be made.
- If decision is to work-up as an outpatient, then do investigations as required for preoperative tests for inpatients.
- Results of investigations to be seen by consultant/doctor on duty.
- Doctor on duty and nurse to organize pre-anesthetic checkup with anesthetist.
- Following this preanesthetic checkup (PAC) will be done by anesthetist in the specified area (Fig. 58.1).
- Upon clearance for surgery admit instructions will be given by the surgeon.
- In the event of an in patient requiring surgery the consultant shall request for pre-anesthetic check up after due work-up.

Fig. 58.1 Preanesthetic checkup

- Preanesthetic checkup will be done at the bed side, if the patient cannot go to the PAC room. Patient is scheduled for surgery after receiving PAC fitness.

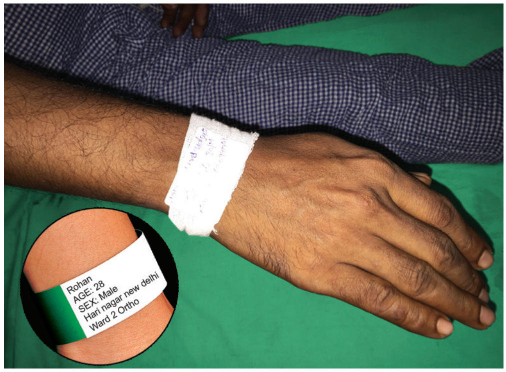


Fig. 58.2A Patient identification mark

Fig. 58.2B Limb identification mark

Fig. 58.3 Preoperative hair removal

ON ADMISSION TO THE WARD

- Common preoperative preparative instruction followed by nurse on duty are:
  - Nil per orally.
  - Consent for the surgery.
  - Preoperative prophylactic antibiotic after sensitivity testing.
  - Any other premedication like anticoagulant, anti-anxiety, etc. as advised by anesthetist.
  - Preparation of the part as per direction of surgeon.
  - Medicines taken by the patient for co morbid condition has to be taken or stopped before surgery (as advised by physician/anesthetist)
  - Arrangement for blood or blood product if advised.
  - Apply patient and limb identification mark (Figs 58.2A and B).
  - Prepare patient in OT dress and send to OT on time with all records.

PRINCIPLE OF OPERATIVE SITE PREPARATION

- *Rationale for hair removal:*
  - Preoperative hair removal by any means is associated with increased surgical site infection rates.
  - Hairs should not be removed unless it interferes with the surgical procedure.
  - If hair removal is required, clipper should be used and not razor.
  - The hair removal should be done as close to the time of surgical procedure as possible (Fig. 58.3).
- *Extent of site preparation:* It should be specified by surgeon.
  - *Lower extremities:* Clean and trim the toenails and remove nail polish, shave the extremity. If surgery has to be performed around hip, clean perineum and perianal area also.
  - *Posterior spine surgery:* Prepare from the hairline to the bottom of the buttocks and to the bedline on both sides.

- *Upper extremities:* Remove rings, clean and trim nails and remove nail polish. Check that the identification bracelet is on the unaffected arm. If surgery has to be performed around shoulder, prepare from past the midline on the back to past the midline of the chest including axilla.

GUIDELINES FOR DISCONTINUATION OF DRUGS

- Some medicines can be dangerous when taken just before or after surgery. There are few drugs which are advised to be stopped before surgery but the time when these drugs should be stopped should be decided by physician and anesthetist.
  - Aspirin, clopidogrel or other anticoagulants or antiplatelet drugs—these drugs can increase bleeding during surgery.
  - Non-steroidal anti-inflammatory drugs (NSAIDs) for example, Ibuprofen, Naproxen, Celecoxib and Meloxicam. These drugs can increase bleeding during surgery by decreasing one's ability to clot blood. They can also slow down bone healing after surgery.
  - Certain steroids before or after surgery. These can also slow down wound and/or bone healing after surgery.
  - Hormone replacement therapy (HRT) and/or birth control pills (OCP) after surgery. These may increase the risk of having blood clots after surgery.
  - Certain over-the-counter (OTC) supplements and/or herbal preparations before surgery. Many of these agents can increase bleeding during surgery.
  - Oral hypoglycemics taken by diabetic patients have to be omitted on the morning of surgery to avoid hypoglycemia during or after surgery.
  - Nicotine and nicotine like products are well known for their vasoconstriction effect hence patients should stop using nicotine-containing products well before surgery.

CHECKLIST REGARDING PATIENT PREPARATION (FIG. 58.4)

- The patient will be brought to the OT with the complete preoperative check list records/folder. The holding room and the circulating nurse will check in the patient and follow these steps:
  - The patient should be greeted with a smile and provide support and reassurance.
  - Patient's name, medical record number and surgeon has to be verified with armband or face sheet by the staff nurse posted in preoperative room.
  - Operative consent has to be checked for completion and accuracy. Verify that appropriate consent forms are completed.
  - Verify surgeon, operative procedure and operative site.
  - Check for the presence of prosthetic or loose teeth, contact lenses or intraocular lens implants; prosthesis (arm, leg, eye), hairpins or clips, jewelry or personal clothing items.

Fig. 58.4 Patient being carried to OT

- *The patient may be taken to the assigned operating room*: The chart is complete; the patient is identified and prepared; anesthesiologist, surgeon and assistant are present.
- If there is a delay, the patient is kept in the holding room. The patient is made as comfortable as possible by offering a warm blanket and reassurance. The patient will remain under constant observation during the delay.

AFTER TAKING THE PATIENT IN OT (FIG. 58.5)

After the patient is taken inside the operation theater, and on OT table, anesthetist takes over. Monitors are attached and the desired anesthesia technique is followed. The common anesthetic procedure are:

- *General anesthesia (GA):*
  - It is the most widespread and established anesthetic technique which can be used for any surgery.
  - The patient is given few intravenous medications to make him unconscious and then breathing is controlled or assisted by using either an endotracheal tube or a laryngeal mask airway.
  - One of the inhalational anesthetic agents (such as halothane, sevoflurane, etc.) is given with oxygen and nitrous oxide to the patient to maintain anesthesia.

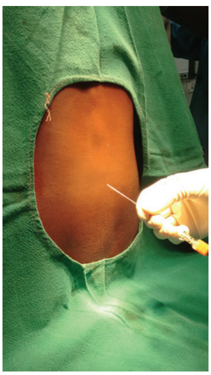


Fig. 58.5 Anesthesia procedure (spinal anesthesia)

  - At the end of surgery, all anesthetic agents are stopped and 100% oxygen is provided.
  - GA is required for children, spine surgeries, or in patients who are not willing or have some contraindication to regional anesthesia.
- *Neuraxial anesthesia (Spinal and epidural anesthesia):* These are a good option for lower limb procedures.
  - In spinal anesthesia, sub arachnoid space is located and after ensuring free flow of cerebrospinal fluid (CSF), 2-4 mL of local anesthetic (bupivacaine or ropivacaine) is injected. The effect is immediate and lasts for 1-2 hours depending on the type and dose of drug used.
  - For epidural anesthesia, epidural space is located and a small bore catheter is placed through which repeated doses of local anesthetics like lignocaine or bupivacaine are given. The effect is delayed (10–20 minutes after injecting local anesthetic).
  - For many cases, a combined spinal epidural anesthesia is given. The advantages of spinal anesthesia (speed of onset, density of block) are therefore combined with those of epidural anesthesia (flexibility, the ability to extend for intraoperative or postoperative analgesia).
- *Regional nerve blocks:*
  - These blocks can be done either by placement of an indwelling catheter with continuous medicine delivery or by a single injection of local anesthetics around the nerves involved, after eliciting paraesthesia or more recently under ultrasound guidance. For example, brachial plexus block for upper limb surgeries.
- *Monitored anesthesia care:*
  - This technique involves anesthesia team giving intravenous sedation to complement the local anesthesia infiltration by surgeon.
  - Close monitoring is needed.

- *Local anesthesia:*
  - Anesthetist is usually not involved.
  - Local anesthetic is infiltrated by the surgeon for small surgical procedures of hand or foot.
- Once the patient is anesthetized (regional nerve block, spinal anesthesia or general anesthesia), tourniquet is applied on the desired extremity.

PATIENT POSITIONING (FIG. 58.6)

- Now patient is positioned for the particular surgical procedure according to consultation with anesthetist.
- Anesthetist must be attentive during patient positioning.
- Bony prominences must be well padded and circulation must not be impeded.
- *Some common positions are as follows:*
  - *Supine position:* This is the most common position used.
    - Patients are usually anesthetized in this position and modifications are made after the induction of anesthesia.
    - The position of the head shall place the cervical, thoracic and lumbar vertebrae in a straight, horizontal line. A small pad or pillow placed under the head allows the muscles to relax and prevent neck strain.

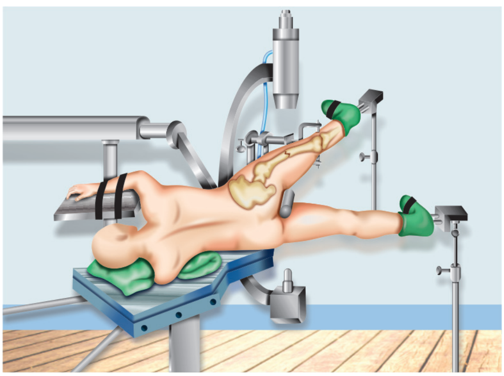


Fig. 58.6 Patient positioning

    - Hips shall be parallel. Legs are placed parallel and uncrossed to prevent compromised circulation and nerve damage. The legs shall be slightly separated so that skin surfaces are not in contact. The heels may need to be padded with foam protectors, if the procedure is expected to be lengthy.
    - Arms are usually placed on arm boards, at less than a 90° angle to the body. The palms shall be turned upwards to diminish the pressure on the brachial and ulnar nerve.
    - The patient's eyes must be protected from pressure and corneal drying or abrasions.
    - Variations of the supine position include **Trendelenburg**, **Reverse Trendelenburg** positions. In all of the variations, the principles remain the same.
  - Prone position—here patient lies with abdomen on the surface of the operating table. Steps to follow for prone positioning:
    - In preparation for placing a patient in prone position, two chest rolls and two pillows must be available.
    - The patient is placed supine on a stretcher and then rolled on the OT table with the help of four assistants taking care of head, neck and cervical spine.
    - An arm board is provided on each side of the table and the patient's arms are brought down and forward to rest with elbows flexed and hands pronated at either side of the head.
    - The head is positioned on a foam pillow or doughnut, keeping the neck in alignment with the spinal column. The eyes are protected from the pillow and the drapes.
  - *Fracture table:* The Operating fracture table are commonly used for surgeries over lower limb requiring C-arm or fluoroscopy.

- The patient rests with the injured leg restrained in a boot-like device. The leg may be rotated, pulled into traction or released, as the surgery requires.
- The unaffected leg rests in a padded foot holder.
- A center post is placed at the perineum and is well padded.

SURGEON PREPARATION

- Surgeon should meet the patient preoperatively to allay the anxiety and to assure him.
- Besides mental preparation for surgery including plan and technique, physical preparation is required to prevent wound infection.
- The washed OT clothes and OT boots along with OT cap and mask, are to be worn before entering the sterile zone of OT.
- Eye shields, plastic aprons and long boots are preferable to prevent the direct contact of surgeon with the infective body fluids. Universal precautions must be followed.
- OT should be first inspected for readiness and the availability of required instruments and implants must be confirmed beforehand.
- *Handwashing:* Handwashing is an important, cheap and a simple way of preventing nosocomial infections. Bacteria on the hands of surgeons can cause wound infections if introduced into the operative field during surgery. The rapid multiplication of bacteria occurs under surgical gloves if hands are washed with a nonantimicrobial soap. However, bacterial growth is slowed after preoperative scrubbing with an antiseptic agent.
  - *Before handwashing:* Any accessories like watch, rings, bracelets should be removed. Keep clothing away from sink and splashes. Adjust water temperature. Keep arms level and well away from body and hands up above elbows for duration of scrub.
  - Povidone-iodine 5–10% is widely used for handwashing, as it is regarded as a safe and an effective antiseptic agent. The majority of iodophor preparations used for hand hygiene contain 7.5–10% povidone-iodine.
  - *Prewash:* Wet hands and forearms; apply sufficient water and work up lather; wash from fingertips to three inches above elbows; clean nails and subungual areas; rinse hands and forearms thoroughly.
  - *Handwashing technique:* There are six main steps for handwashing (Fig. 58.7).
    - *Step-1*: Palm to palm rubbing
    - *Step-2*: Rubbing with palm of one hand over dorsum of other and vice-versa
    - *Step-3*: Rubbing as palm to palm and finger interlaced.
    - *Step-4*: Rubbing as back of fingers to opposing palms and finger interlocked
    - *Step-5*: Rotational rubbing of one thumb clasped in another palm and vice-versa
    - *Step-6*: Rotational rubbing backwards and forward with clasped finger of one hand in the palm of another and vice-versa.
- *Gown and gloves (Fig. 58.8):*
  - After properly drying the hands with a sterile towel, the surgeon should wear a sterile gown with the proposed technique. Nurse will assist the surgeon to wear the gown properly and then to tie it.
  - Sterile pair of gloves of appropriate size for surgeon should be worn with the aseptic technique. Some surgeons prefer two pair of gloves.

SURGICAL SITE PREPARATION BY SURGEON BEFORE SURGERY (FIGS 58.9A TO E)

- Patient's preoperative skin preparation:
  - Skin preparation should be done with a fast-acting, broad-spectrum, and persistent antiseptic-containing preparation that substantially reduces

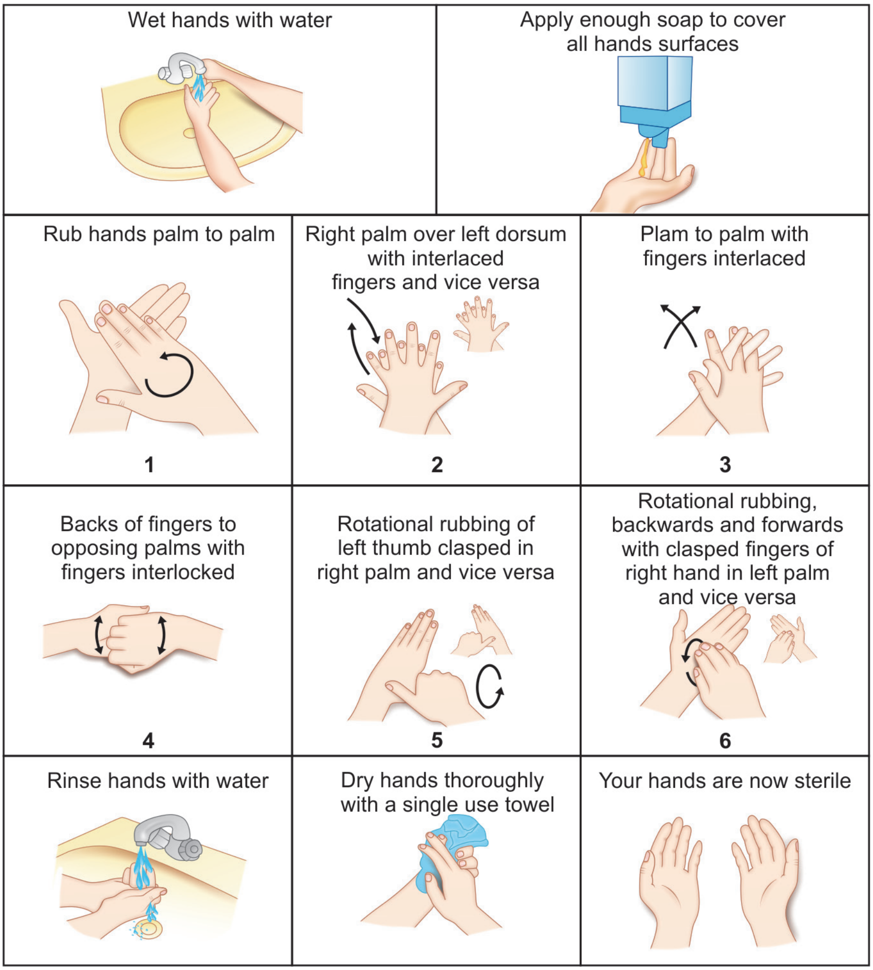
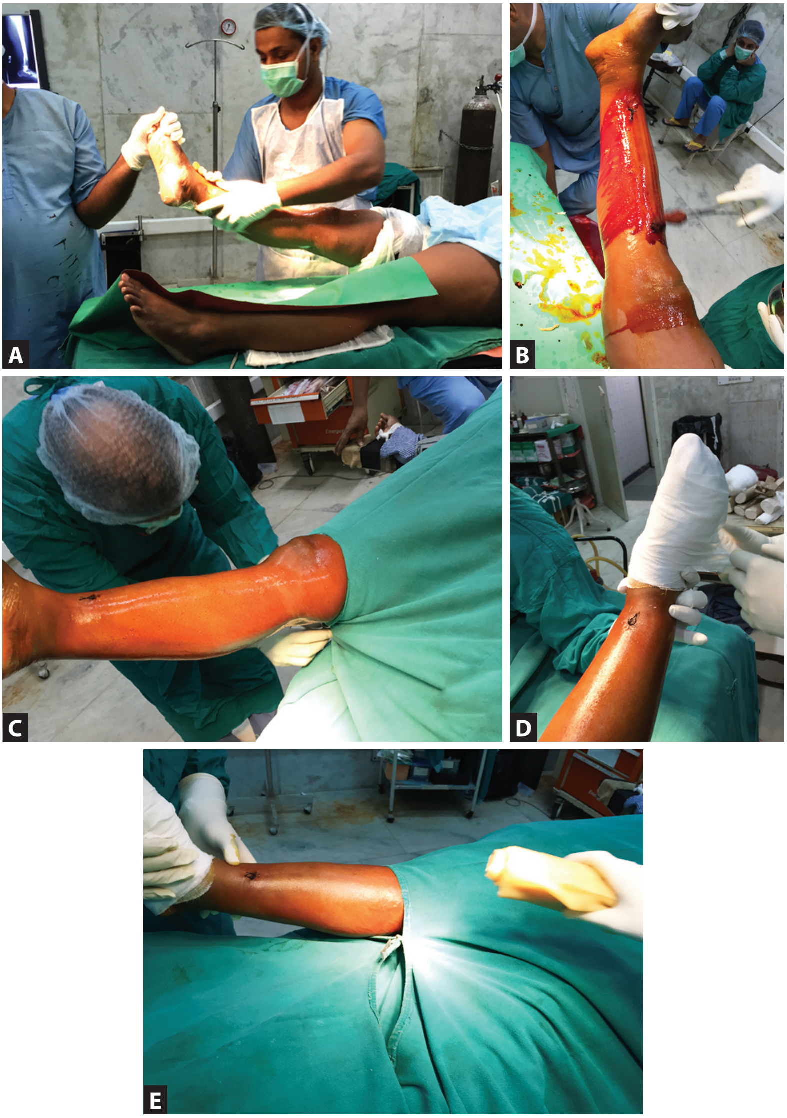


Fig. 58.7 Handwashing technique

Fig. 58.8 A fully prepared surgeon

the number of microorganisms on intact skin. Chlorhexidine gluconate and iodophors are commonly used antimicrobials that fit in this category.

- The skin should be scrubbed, starting at the site of incision, with circular motion to the periphery.
- Use enough pressure and friction to remove dirt and micro-organisms from the skin and pores.
- Discard the sponge after reaching the periphery. Never bring a soiled sponge back toward the center of the area.



Figs 58.9A to E Steps of surgical site preparation

World Health Organization

SURGICAL SAFETY CHECKLIST (FIRST EDITION)

Before induction of anaesthesia ▸▸▸▸▸▸▸▸▸	Before skin incision ▸▸▸▸▸▸▸▸▸▸▸▸▸▸	Before patient leaves operating room
SIGN IN	**TIME OUT**	**SIGN OUT**
☐ **PATIENT HAS CONFIRMED** • IDENTITY • SITE • PROCEDURE • CONSENT ☐ **SITE MARKED/NOT APPLICABLE** ☐ **ANAESTHESIA SAFETY CHECK COMPLETED** ☐ **PULSE OXIMETER ON PATIENT AND FUNCTIONING** **DOES PATIENT HAVE A:** **KNOWN ALLERGY?** ☐ NO ☐ YES **DIFFICULT AIRWAY/ASPIRATION RISK?** ☐ NO ☐ YES, AND EQUIPMENT/ASSISTANCE AVAILABLE **RISK OF >500ML BLOOD LOSS (7ML/KG IN CHILDREN)?** ☐ NO ☐ YES, AND ADEQUATE INTRAVENOUS ACCESS AND FLUIDS PLANNED	☐ **CONFIRM ALL TEAM MEMBERS HAVE INTRODUCED THEMSELVES BY NAME AND ROLE** ☐ **SURGEON, ANAESTHESIA PROFESSIONAL AND NURSE VERBALLY CONFIRM** • PATIENT • SITE • PROCEDURE **ANTICIPATED CRITICAL EVENTS** ☐ **SURGEON REVIEWS:** WHAT ARE THE CRITICAL OR UNEXPECTED STEPS, OPERATIVE DURATION, ANTICIPATED BLOOD LOSS? ☐ **ANAESTHESIA TEAM REVIEWS:** ARE THERE ANY PATIENT-SPECIFIC CONCERNS? ☐ **NURSING TEAM REVIEWS:** HAS STERILITY (INCLUDING INDICATOR RESULTS) BEEN CONFIRMED? ARE THERE EQUIPMENT ISSUES OR ANY CONCERNS? **HAS ANTIBIOTIC PROPHYLAXIS BEEN GIVEN WITHIN THE LAST 60 MINUTES?** ☐ YES ☐ NOT APPLICABLE **IS ESSENTIAL IMAGING DISPLAYED?** ☐ YES ☐ NOT APPLICABLE	**NURSE VERBALLY CONFIRMS WITH THE TEAM:** ☐ **THE NAME OF THE PROCEDURE RECORDED** ☐ **THAT INSTRUMENT, SPONGE AND NEEDLE COUNTS ARE CORRECT** (OR NOT APPLICABLE) ☐ **HOW THE SPECIMEN IS LABELLED** (INCLUDING PATIENT NAME) ☐ **WHETHER THERE ARE ANY EQUIPMENT PROBLEMS TO BE ADDRESSED** ☐ **SURGEON, ANAESTHESIA PROFESSIONAL AND NURSE REVIEW THE KEY CONCERNS FOR RECOVERY AND MANAGEMENT OF THIS PATIENT**

THIS CHECKLIST IS NOT INTENDED TO BE COMPREHENSIVE. ADDITIONS AND MODIFICATIONS TO FIT LOCAL PRACTICE ARE ENCOURAGED.

Fig. 58.10 WHO surgical safety checklist

 – Repeat the scrub with a separate sponge for each round.

- Draping with sterile sheets, exposing only the operative area has to be done properly.
- The patient and the surgical site must be confirmed once again before applying the knife.

WHO SURGICAL SAFETY CHECKLIST (FIG. 58.10)

- The WHO Surgical Safety Checklist was introduced in 2008, and has since revolutionized patient safety and the whole culture of surgical practice across the world.

SECTION

8

Glorious History of Orthopedics

Upendra Kumar

Chapters

CHAPTER

59

Era before Roentgen

AMBROISE PARÉ (1510–1590) (FIG. 59.1)

- Paré was born in France.
- He is known as father of French surgery.
- *Contribution:*
  - He developed various methods for wound care.
  - He used vascular ligature during amputation.

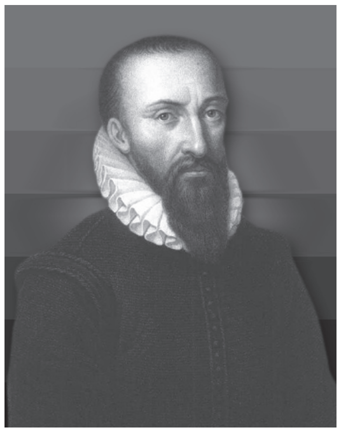


Fig. 59.1 Ambroise Paré

NICOLAS ANDRY (1658–1742) (FIG. 59.2)

- Andry was born in Lyon, France.
- He was professor of medicine at Paris University.
- Andry is honored as father of orthopedics.
- *Contribution:*
  - He coined the term orthopedics (orthos means straight and pedis means child)
  - He also illustrated a famous orthopedic symbol called Tree of Andry.
  - He wrote a famous book "orthopaedia" on prevention and correction of deformity in children.

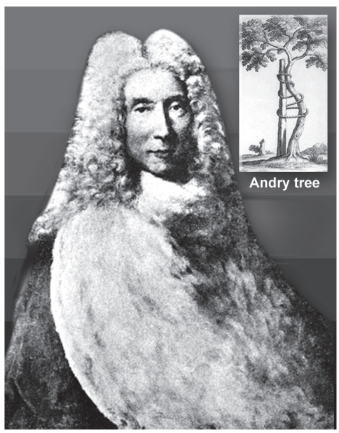


Fig. 59.2 Nicolas Andry

PERCIVALL POTT (1714–1788) (FIG. 59.3)

- Pott was born in London, England.
- He worked in St. Bartholomew's hospital.
- *Contribution:*
  - *Pott's fracture:* He had his own bimalleolar fracture of distal tibia which became famous with the name of Pott afterwards.
  - *Pott's disease:* He emphasized that paraplegia due to spinal tuberculosis is secondary to lung ailment.

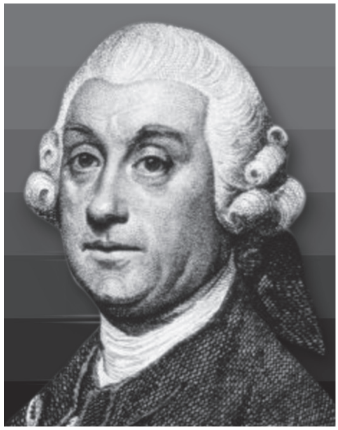


Fig. 59.3 Percival Pott

JOHN HUNTER (1728–1793) (FIG. 59.4)

- Hunter was born in Scotland.
- He worked as British army surgeon.
- Hunter used to say do not think try the experiment. Royal Society of Surgeon started Hunterian lecture in honor of this surgeon.
- *Contribution:*
  - He had gone through tendoachilles rupture of his own and later he developed the method of conservative treatment.
  - He studied over mechanism and stages of fracture healing.
  - He wrote a title "a treatise on blood, inflammation and gunshot wounds".

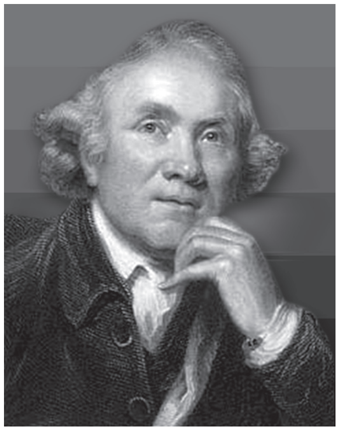


Fig. 59.4 John Hunter

WILLIAM HEY (1736–1819) (FIG. 59.5)

- Hey was born in Pudsey, Great Britain.
- He was surgeon at Leeds General Infirmary.
- *Contribution:*
  - He described the subacute osteomyelitis of tibia.
  - He coined the term internal derangement of knee and explained about meniscal injuries and loose bodies.
  - He introduced tarsometatarsal amputation.

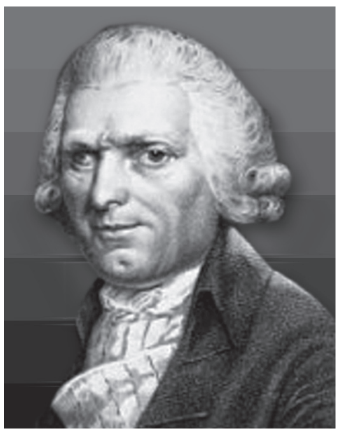


Fig. 59.5 William Hey

GIOVANNI BATTISTA MONTEGGIA (1762–1815) (FIG. 59.6)

- Monteggia was born in Italy.
- He worked as surgeon and professor in Milan.
- *Contribution:*
  - He described the proximal ulnar fracture called Monteggia fracture.

Fig. 59.6 Giovanni Battista Monteggia

ABRAHAM COLLES (1773–1843) (FIG. 59.7)

- Colles was born in Kilkenny, Ireland.
- He worked as professor of surgery at college of surgeon in Dublin.
- *Contribution:* He described extra-articular fracture distal radius, now famously known as Colles fracture.

Fig. 59.7 Abraham Colles

BARON GUILLAUME DUPUYTREN (1777–1835) (FIG. 59.8)

- Dupuytren was born in central France.
- He worked as a Military surgeon and anatomical pathologist.
- *Contribution:*
  - He described the two famous term Dupuytren's fracture-fracture around ankle and Dupuytren's contracture-contracture of palmar fascia.
  - He wrote on many subjects such as congenital dislocation of hip, subungual exostosis, tenotomy in torticollis and differentiating feature between spina ventosa and osteosarcoma.

Fig. 59.8 Baron Guillaume Dupuytren

SIR BENJAMIN BRODIE (1783–1862) (FIG. 59.9)

- Brodie was born in Winterslow, England.
- He worked at St George hospital over a period of thirty years.
- *Contribution:*
  - He described a bone abscess that is called Brodie's abscess after his name.
  - He wrote a famous title "On the disease of joint".
  - He introduced the fellowship exam FRCS, a most recognized degree in the field of surgery.

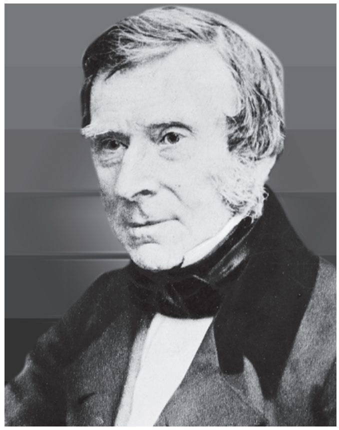


Fig. 59.9 Sir Benjamin Brodie

SIR JOHN RHEA BARTON (1794–1871) (FIG. 59.10)

- Barton was born in Pennsylvania, North America.
- He worked in Pennsylvania hospital as surgeon.
- He is referred as father of American surgery.
- *Contribution:*
  - He is well known for his corrective osteotomies around ankylosed hip.
  - He described the Barton's fracture in distal radius.
  - He also developed the technique of wiring around patella.

Fig. 59.10 Sir John Rhea Barton

JAMES SYME (1799–1870) (FIG. 59.11)

- Syme was born in Edinburgh, England.
- He worked as professor of surgery in Edinburgh.
- *Contribution:*
  - He introduced a technique of amputation around ankle is known as Syme's amputation.
  - He wrote a treatise over ankle joint amputation.

Fig. 59.11 James Syme

ANTONIUS MATHIJSEN (1805–1878) (FIG. 59.12)

- Mathysen was born in Budel, Netherland.
- He worked as Dutch military surgeon.
- *Contribution:* He introduced plaster of Paris (POP) bandage.

Fig. 59.12 Antonius Mathysen

ROBERT WILLIAM SMITH (1807–1873) (FIG. 59.13)

- Smith was born in Dublin, Ireland.
- He worked as surgeon but he used to taught in Richmond hospital Dublin.
- *Contribution:*
  - He introduced a special type of fracture in distal radius which was just opposite to Colles's fracture in every manner.
  - He also described about Madelung's deformity and Neurofibromatosis.
  - He wrote a title named "a treatise on fracture in the vicinity of joints and on certain forms of accidental and congenital dislocation."

Fig. 59.13 Robert William Smith

WILLIAM JOHN LITTLE (1810–1894) (FIG. 59.14)

- Little was born in England.
- He spent his time as surgeon and was founder of Royal Orthopedic Hospital in London.
- *Contribution:*
  - He popularized the technique of subcutaneous tenotomy for treatment of neuroparalytic disorder what he learnt from Louis Stromeyer in Germany.
  - Spastic diplegia in cerebral palsy child is also called as Little's disease.
  - He also described about pseudomuscular dystrophy.

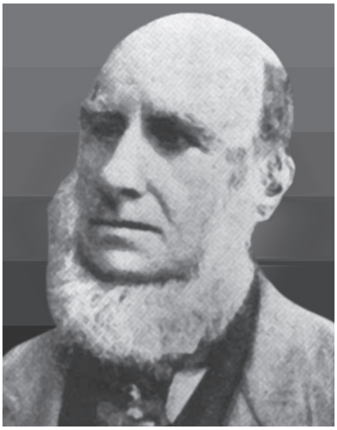


Fig. 59.14 William John Little

JEAN-MARTIN CHARCOT (1825–1893) (FIG. 59.15)

- Charcot was born in Paris, France.
- He worked in Pitie-Salpetriere hospital as designated as first professor in neurosurgery.
- *Contribution:*
  - He wrote a thesis distinguishing among gouty arthritis, rheumatoid arthritis and osteoarthritis.
  - He introduced a peculiar type of arthritis in ankle now known as Charcot arthropathy.
  - He wrote much about amyotrophic lateral sclerosis, tabes dorsalis, motor neuron disease and many psychiatric disorders.

Fig. 59.15 Jean-Martin Charcot

EMIL THEODOR KOCHER (1841–1917) (FIG. 59.16)

- Kocher was born in Bern, Switzerland.
- He worked as professor of surgery in University of Bern and director of the university surgical clinic at the Inselspital.
- He was awarded with Nobel prize (1909) for his contribution in medical science.
- *Contribution:*
  - He introduced Kocher's maneuver for reduction of anterior dislocation of shoulder, Kocher's criteria of septic arthritis and Kocher's incision around elbow.
  - He also designed many surgical instruments like Volkmann scoop.
  - He wrote a very famous book "A Textbook of Operative Surgery".

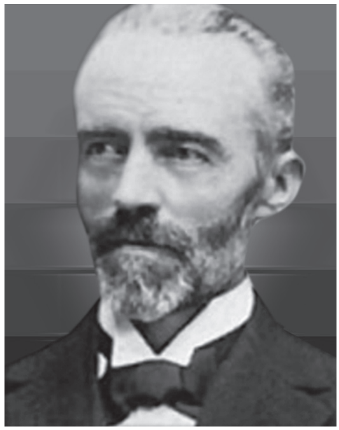


Fig. 59.16 Emil Theodor Kocher

SIR JAMES PAGET (1814–1899) (FIG. 59.17)

- Paget was born in England.
- He worked as surgeon and teacher but his lecture in Bartholomew's hospital had elevated its level in that period.
- *Contribution:*
  - He described a bone pathology what he called osteitis deformans and incidence of osteosarcoma in it, now called as Paget's disease.
  - Suspension of upper limb in post-operative cases.

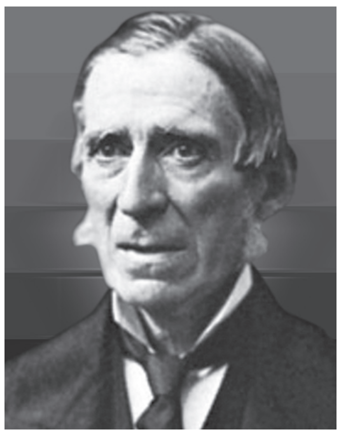


Fig. 59.17 Sir James Paget

RICHARD VON VOLKMANN (1830–1889) (FIG. 59.18)

- Volkmann was born in Leipzig Germany.
- He worked as professor of surgery and director of the surgical clinic at Halle.
- *Contribution:*
  - He expanded the principle of antiseptic surgery given by Lister.
  - He wrote his famous paper on ischemic muscular paralyses and contractures, later it become famous as Volkmann ischemic contracture.
  - He developed many surgical instruments.

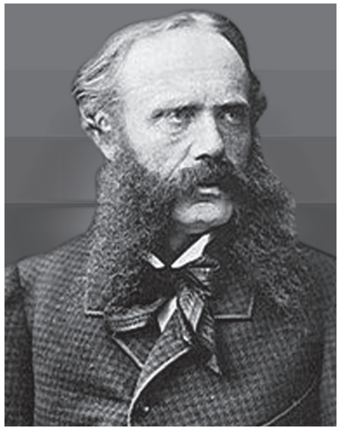


Fig. 59.18 Richard Von Volkmann

HUGH OWEN THOMAS (1834–1891) (FIG. 59.19)

- Thomas was born in Welsh, Great Britain.
- He spent most of his time as private practitioner of surgery in Liverpool.
- He is considered as father of British Orthopedic Surgery.
- *Contribution:*
  - He advocated for prolonged and uninterrupted bed rest for treatment of tuberculosis patient.
  - He developed various type of splint like cervical collar, knee splint, metatarsal bar, heel wedge, etc.
  - He was first to developed a method to reveal the concealed fixed flexion deformity in hip joint, now called as Thomas's test.

Fig. 59.19 Hugh Owen Thomas

FRIEDRICH TRENDELENBURG (1844–1924) (FIG. 59.20)

- Trendelenburg was born in Berlin, Germany.
- He worked as surgeon at university of Rostok, University of Bonn and University of Leipzig.
- *Contribution:*
  - He was the man to describe the loss of abductor lever arm mechanism in hip pathology and developed a test to reveal it, called Trendelenburg test.
  - The special gait pattern of such patient was designated as Trendelenburg gait.

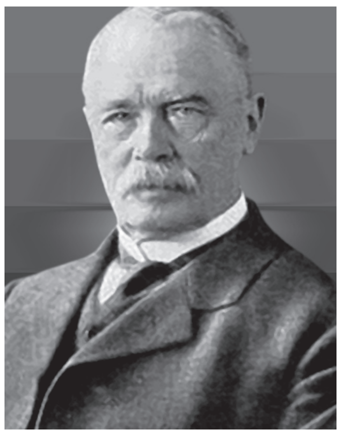


Fig. 59.20 Friedrich Trendelenburg

CHAPTER

60

Era after Roentgen

Wilhelm Conrad Roentgen, (1845–1923)—was a professor of physics at Wurzburg, Germany. He invented the X-ray that changed the era of orthopedics. The first radiograph that Roentgen took of his wife hand on December 22 in year 1895. He presented this picture to his wife on eve of the coming Christmas. Roentgen was awarded with Nobel Prize for this invention in year 1895.

SIR ROBERT JONES (1857–1933) (FIG. 60.1)

Fig. 60.1 Sir Robert Jones

- Robert Jones (nephew of HO Thomas) was born in Wales, Great Britain.
- He worked for a long period as military surgeon during First World War.
- It was said when Jones operated time stood still.
- He is honored as father of Modern orthopedics.
- *Contribution:*
  - He introduced the Jones fracture.
  - He developed a tendon transfer technique (Jones technique) for wrist drop.
  - He first reported the use of X-ray for localization of bullet in the wrist.
  - His book "Textbook of Orthopedics" is said to be the first systematic treatise to deal with diagnosis and management of fracture.

MARTIN KIRSCHNER (1879–1942) (FIG. 60.2)

- Kirschner was born in Breslau, Germany.
- He worked as Professor of Surgery at Königsberg and Tübingen.
- *Contribution:*
  - He introduced the K-wire, the most versatile implant of orthopedics.
  - He also developed a method for opening of knee joint.

Fig. 60.2 Martin Kirschner

WILLIS CAMPBELL (1880–1941) (FIG. 60.3)

- Campbell was born in Mississippi, USA.
- He worked as Orthopedic Surgeon in University of Tennessee-Memphis and established Campbell Clinic in year 1909.
- *Contribution:*
  - He introduced interpositional arthroplasty.
  - He wrote his famous treatise "Campbell's operative orthopedic the master book in the field of orthopedic.
  - He was founder president of American Orthopedic Association.

Fig. 60.3 Willis Campbell

THOMAS PORTER MCMURRAY (1887–1949) (FIG. 60.4)

- McMurray was born in London, England.
- He worked as Lecturer in University of Liverpool and became the first professor of of Orthopedic Surgery when Robert Jones succeeded to Director of Orthopedic there.
- It is said that he could remove the entire meniscus in 5 minutes and disarticulate the hip in 10 minutes.
- *Contribution*:
  - He introduced McMurray medial displacement osteotomy in nonunion fracture neck femur.
  - He also developed McMurray test to identify the meniscal injury.

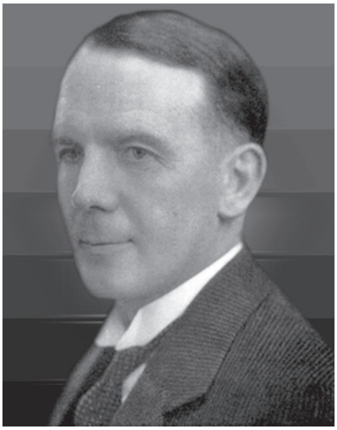


Fig. 60.4 Thomas Porter McMurray

AUSTIN T MOORE (1899–1963) (FIG. 60.5)

- Moore was born in Columbia, United States of America.
- He worked as Orthopedic Surgeon in Columbia Hospital in South Carolina.
- *Contribution:* He performed the first hip replacement surgery with metallic implant. This implant was improved due course of time and now known as Austin Moore prosthesis.

Fig. 60.5 Austin T Moore

GERHARD KUNTSCHER (1900–1972) (FIG. 60.6)

- Kuntscher was born in Zwickau, Germany.
- He worked as Military Surgeon during second World War.
- *Contribution:*
  - He introduced intramedullary nailing for long bones. His Kuntscher nails revolutionized the treatment of fracture femur.
  - He and his technical team developed many instruments for IM nailing.
  - He wrote a famous title "Practices of Intramedullary Nailing" a mother book in the field of intramedullary nailing.

Fig. 60.6 Gerhard Kuntscher

SIR REGINALD WATSON-JONES (1902–1972) (FIG. 60.7)

- Watson Jones was born in Brighton, England.
- He worked as surgeon and teacher both but spent most of his time at Shropshire Orthopedic Hospital in Oswestry, later called Robert Jones and Dame Agnes Hunt Hospital.
- *Contribution:*
  - He published a title "Fracture and Joint Injuries" that was translated in many languages and remained a standard reference for a long period.
  - He was the first editor of the British volume of the Journal of Bone and Joint Surgery.

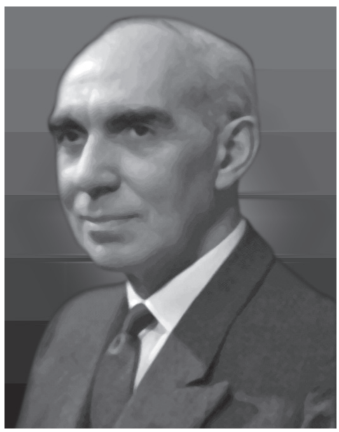


Fig. 60.7 Sir Reginald Watson-Jones

SIR JOHN CHARNLEY (1911–1982) (FIG. 60.8)

- Charnley was born in Lancashire, England.
- He worked as Professor in Department of Orthopedic Surgery at University of Iowa Hospitals and Clinics.
- *Contribution:*
  - He introduced "three point molding principle" for reduction and maintenance of long bone fractures.
  - His book "The closed treatment of common fractures" proved a basic book for understanding of conservative treatment of fractures.
  - He introduced a new technique of subcortical cancellous bone-grafting by raising a osteoperiosteal flap in cases of nonunion.
  - He was pioneer in the field of successful total hip arthroplasty and introduced Charnley's retractor and Charnley's hip prosthesis.

Fig. 60.8 Sir John Charnley

AMULYA KUMAR SAHA (1913–2000) (FIG. 60.9)

- Saha was born in Pabna, undivided India now in Bangladesh.
- He worked as Director-professor of surgery and honorary professor, consultant and emeritus professor orthopedic surgery in Nil Ratan SirCar Medical College and Hospital, Kolkata.
- He also became the President of Indian Orthopaedic Association.
- *Contribution:*
  - He discovered the Zero position of glenohumeral joint and given Hunterian lecture over it for its recognition and clinical importance.
  - Kinetics and kinematics of shoulder joint, Saha functional classification of muscle,

Fig. 60.9 Amulya Kumar Saha

Saha's method of reduction of anterior shoulder dislocation, Saha's osteotomy for recurrent shoulder dislocation, Saha procedure of trapezius muscle transfer for abduction in paralyzed shoulder are chief contributions attributed with him.

IGNACIO PONSETI (1914–2009) (FIG. 60.10)

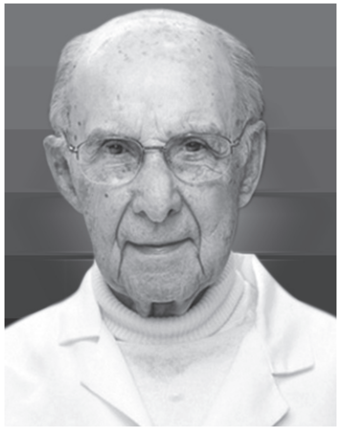


Fig. 60.10 Ignacio Ponseti

- Ponseti was born in Menorca, Spain.
- He worked as professor in Department of Orthopedic Surgery at University of Iowa Hospitals and Clinics.
- *Contribution:*
  - He described a technique in the form of serial casting followed by bracing for treatment of congenital club foot.
  - The Ponseti International Association for the advancement of clubfoot was founded in year 2006 to improve the treatment of children born with club-foot through education, research and improved access to care.

BISHTU MUKHOPADHYAY (1916–2002) (FIG. 60.11)

Fig. 60.11 Bishtu Mukhopadhyay

- B Mukhopadhyay was born in Patna, India.
- He worked as Professor and Head of Department of Orthopedics in Patna Medical College, Patna, Bihar.
- He was one of the founder members and first Secretary of Indian Orthopaedic Association (IOA) and later occupied the post of President also. He also remained the President of Association of Surgeons of India (ASI).
- He was awarded with Padma Bhushan by Government of India for his contribution in medical education.
- *Contribution:*
  - He advocated the complete soft tissue release in PMSTR technique (Patna procedure) for clubfoot treatment.
  - His work on early intervention in tuberculosis with a case series of more than 800 patients was recognized worldwide and he became the first Indian to deliver the Hunterian lecture in London.
  - He established the first orthopedic and rehabilitation department of the country in Patna Medical College and Hospital, Bihar.
  - In the year 1983, he established the Orthopedic Research and Education Foundation of India.

GAVRIIL ABRAMOVICH ILIZAROV (1921–1992) (FIG. 60.12)

- Ilizarov was born in Bialowieza, Poland.
- He headed the Kurgan Research Institute for Experimental and Clinical Orthopaedics and Traumatology (KNIIEKOT) until 1991.
- *Contribution:* He developed the principle of distraction osteogenesis with help of some rings and wires commonly called Ilizarov apparatus.

Fig. 60.12 Gavriil Abramovich Ilizarov

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